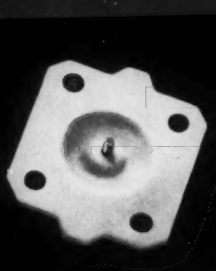
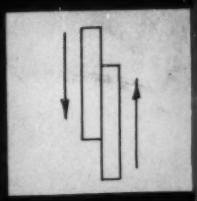
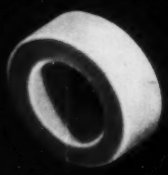
SEPTEMBER 5, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY







Designing with Teflon

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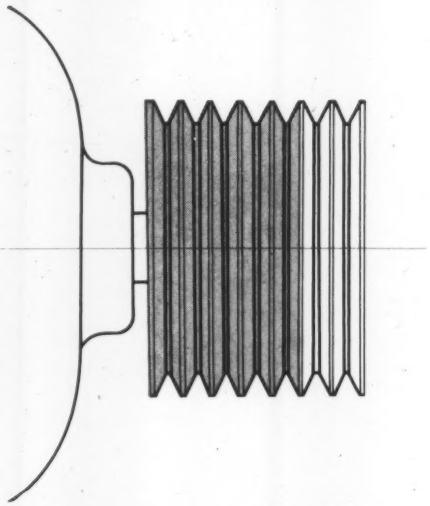
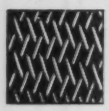
5 Gates Super Vulco Ropes do the work of 7 standard V-belts

Use fewer belts... but get same HP



No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)

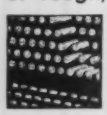


A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)

Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. Tough, resilient Tensile Cords



Super strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

4. High Electrical Conductivity

Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant

Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

Cut sheave width and weight . . . design your drive to benefit from the greater HP capacity of Gates Super Vulco Ropes.

Gates Super Vulco Rope has 40% more horsepower capacity . . . delivers more HP per dollar invested than any standard V-belt. 5 Gates Super Vulco Ropes will do the work of 7 standard V-belts.

Sheaves with fewer grooves cost less . . . weigh less . . . occupy less space. Your drive design is improved.

Helpful drive data is quickly available to you. Simply call your nearby Gates distributor for advice from a Gates V-Belt Specialist. Stocks carried in industrial centers throughout the world.

The Gates Rubber Company
Denver, Colorado

TPA 264A

Gates — The Mark of *Specialized* Research

Gates Super VULCO ROPE Drives

Reader Service No. 301 on page 19

NOW! An Automatic Lubrication System with

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bearing inch capacity

Oil-Mist Unit atomizes oil and distributes it through tubing to all lubricated mechanisms.

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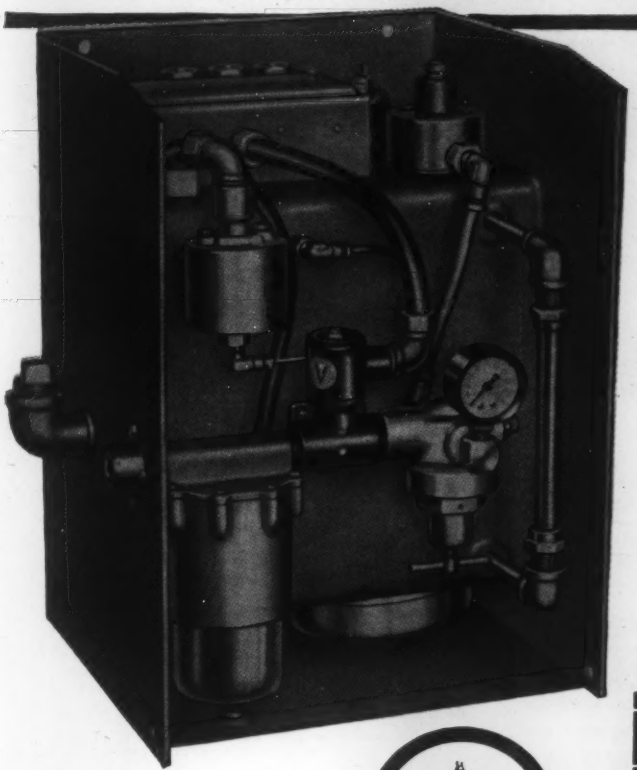
oil-mist



provides safe—sure—continuous—foolproof lubrication!

Large Models Designed for Large Machines! Designed to lubricate up to 500 Bearing inches. (1 Bearing Inch equals 1 inch of Shaft Diameter.)

Big Lubricant Supply! 3-gallon capacity tank holds enough oil to provide a "48-hour week" of continuous lubrication for 500 Bearing Inches.

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☐ Please have your Alemite Lubrication Representative arrange a no-obligation demonstration.

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City ..... State .....

Circle 404 on page 19

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September 5, 1957 Volume 29—No. 18

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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CLARK Type "CY" Starters, sizes 0 and 1, now have higher NEMA horsepower ratings

As shown in the table below, NEMA maximum horsepower ratings for size 0 and 1 AC magnetic across-the-line starters have been increased. Clark Type "CY" starters now available to meet these new standards will, in many cases, permit you to meet your requirements with smaller sizes. You can at once take advantage of the money and space savings made possible by this re-rating.

CHANGES IN NEMA STANDARDS FOR MAXIMUM HORSEPOWER RATINGS OF AC MAGNETIC STARTERS AND CONTACTORS

SIZE AND VOLTAGE RATINGS	MAXIMUM HP RATINGS	
THREE PHASE	OLD	NEW
Size 0 110V	1½	1½
Size 0 208/220V	2	**3**
Size 0 440/600V	3	**5**
Size 1 110V	3	3
Size 1 208/220V	5	**7½**
Size 1 440/600V	7½	**10**
SINGLE PHASE		
Size 0 110V	1	1
Size 0 208/220V	1½	**2**
Size 0 440/600V	2	**3**
Size 1 110V	1½	**2**
Size 1 208/220V	3	3
Size 1 440/600V	5	5

NOTE: HP ratings for plugging and jogging duty have not been revised.

IN ADDITION TO COST AND SPACE SAVING BENEFITS OF THE NEW NEMA RATINGS, CLARK Type "CY" STARTERS OFFER MANY OTHER ADVANTAGES:

Greater Dependability and longer life

- Heavy-duty mill-type construction.
- Large silver-to-silver twin-break contacts.
- Vertical lift, free-floating magnet uses no springs; pull characteristic assures positive contact closing and keeps magnet slam to a minimum.

Easier Maintenance

- Contacts and contact springs quickly and easily inspected—without tools.
- All parts readily accessible and replaceable from front without removal from panel or enclosure—screwdriver and wrench only tools needed.
- Magnet coils easily replaced.

Simplified Installation

- Generous wiring space.
- All terminals face the front.
- Pressure-type terminals line and load.

...and many others

These increased horsepower ratings for AC controls will be adopted for all forms of Clark across-the-line starting equipment.

Revised Clark Catalog sheets and price lists covering the new NEMA ratings are available on request.

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Circle 406 on page 19

Engineering News Roundup

Four Years Plus for Engineers Predicted by College President

Graduate Degrees a Necessity With Background in Humanities

CHICAGO, ILL. — Far-reaching changes in the education of engineers were predicted recently by Dr. John T. Rettaliata, president of Illinois Institute of Technology.

The prospective engineering student can look forward to more emphasis on the sciences and humanities, and less attention to applications during his undergraduate days.

"Specialization will move to the graduate area," he said, and "it will not be too long before a graduate degree is the minimum requirement in engineering, as is the case in the sciences."

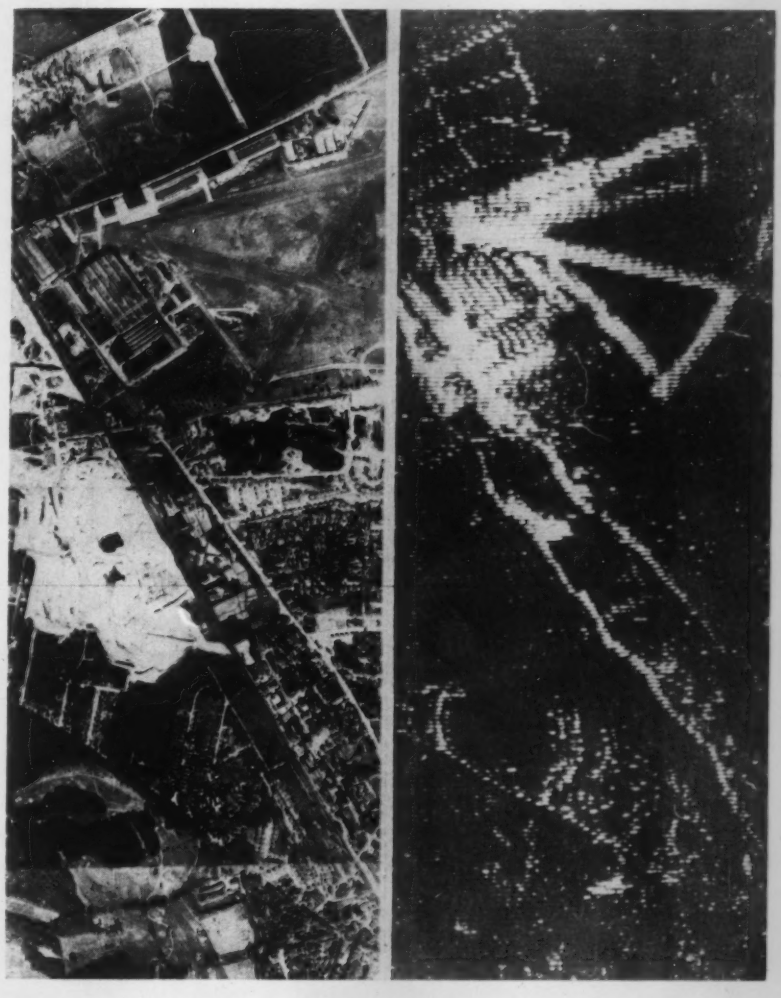
The remarks were made at the opening session of a four-week graduate engineering program sponsored by the Western Electric Co. at Illinois Tech.

"The undergraduate engineering program, as now organized, does not provide the desired depth and breadth of scientific foundation and the background for creative thinking that is so essential in today's fast-moving world," Dr. Rettaliata said. He pointed out that steps are being taken to prepare engineers who are well grounded in fundamentals and possess the ability for creative thinking.

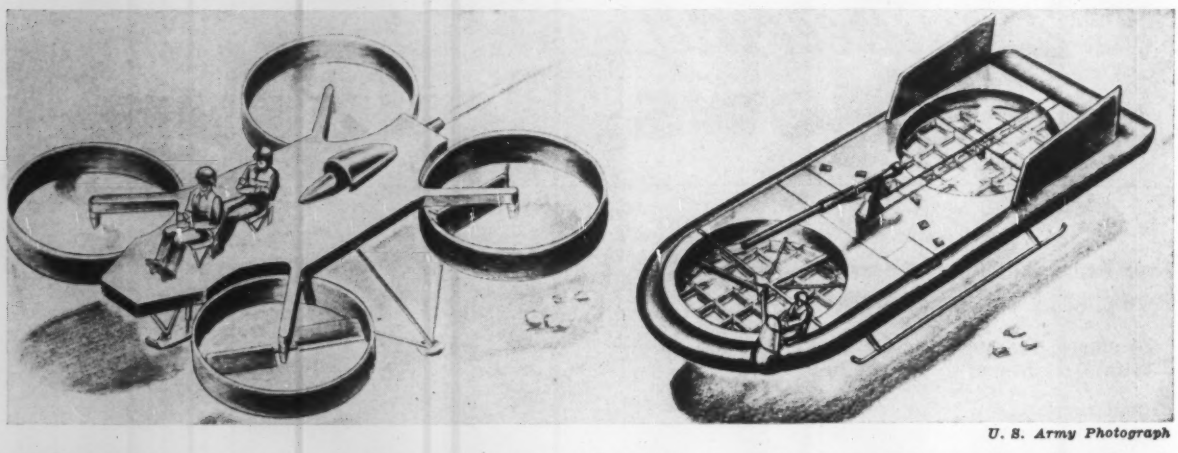
"The effect of these modifications will be to approach unification of the various engineering courses of study at the undergraduate level. The majority of the program will be the same for all engineers, with those courses defining the major field of concentration not exceeding several semesters out of the four years."

Dr. Rettaliata said there is no easy solution to the problem, just as there is no ready answer to the engineering manpower shortage.

He urged engineers and their professional societies to assist in attracting more students to engineering by co-operating with high-school administrators.

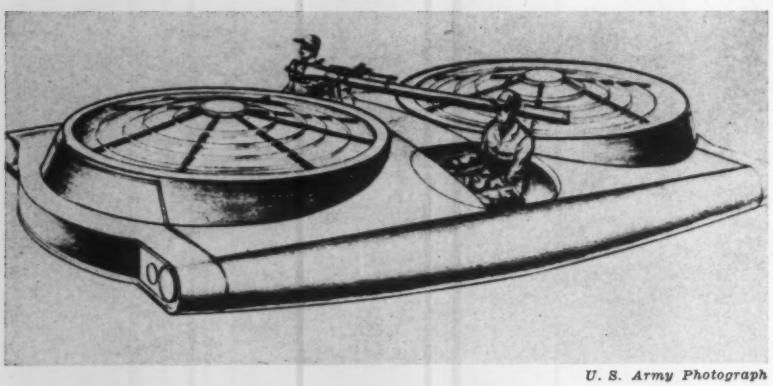


HOT SHOTS like the one above, right, are products of an infrared photographic detection system developed by Servo Corp. of America for the Air Force. On film sensitive to infrared, the radiation from objects is recorded in varied brightness depending on the amount of heat released. Here, a conventional aerial photo of Farmingdale, N. Y., is compared with an infrared exposure of the same area. The thermal map shows the presence and activity of heat generators like airplanes, ground traffic, and industrial plants. The technique is effective either day or night despite camouflage of subjects.



U. S. Army Photograph

FLYING JEEPS have reached design-development stage, according to three recently awarded Army contracts. Army is seeking a general utility vehicle that can stay aloft several hours, travel at 50 mph, carry 1000-lb payload. Preliminary sketches shown here indicate what Aerophysics Development, Chrysler, and Piasecki Helicopter Corp. will attempt to produce individually as flying test models. The vehicle would combine the advantage of helicopter mobility over rough terrain with down-to-earth versatility of conventional jeep. Small vehicle size is obtained through use of ducted propellers which increase propeller efficiency and also provide protection to passengers and ground personnel. If the new idea works, the Army may want "aerial trucks."



U. S. Army Photograph

Breakthrough in Radar Research Ranked Biggest Step Since 1939

Air Defense Strengthened By Considerable Range Increase

NEW YORK, N. Y.—Radar systems "many hundreds of times" more powerful than any in use during World War II are possible through new techniques developed at Columbia University. Dr. John R. Dunning, dean of the Columbia School of Engineering, hailed the recent achievement as "probably the greatest single advance in radar work since the start of World War II and the early British work." The announcement culminates a three-year research project carried out in the Electronic Research Laboratories at Columbia under an Air Force contract.

The new techniques devised by Columbia scientists do not necessitate an increase in power used. Instead, a method of "signal enhancement" is employed which raises the strength of a radar signal reflected from an aircraft or missile to "an unprecedentedly high level." Since the strength of a radar echo decreases as the fourth power of the distance to the target, older radar techniques would achieve increased range only through substantial increases in the amount of power used. For example, if it is necessary to double the range at which an aircraft can be spotted, conventional methods would require a 16-times increase in power. A 10-times increase in range would require an astronomical 10,000-fold increase in power.

Although few details were disclosed, the Air Force-Columbia program was said to utilize fundamental principles of communication theory to achieve its results. The experimental system was described as a unique radar transmitter which generates a carefully controlled signal and a receiver which "enhances" the echo signal. Much of the theoretical basis for the work had been established by numerous researchers during the post-World War II period. Dr. R. I. Bernstein of Columbia served as overall co-ordinator of the project. Mr. John H. Bose directed research on the transmitter, and

Front Cover

Exceptional chemical resistance, bearing characteristics, and electrical properties of tetrafluoroethylene (Teflon) plastics are the subjects of George Farnsworth's front cover. A series of four articles on Teflon starts in this issue on Page 86.

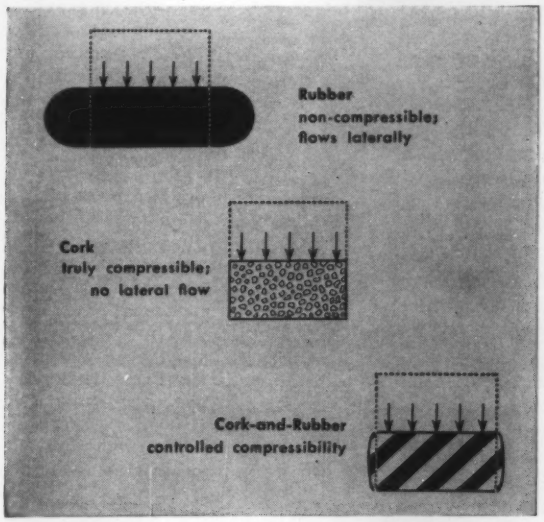
How to cut the cost of O-rings

Lathe-cut, compressible cork-and-rubber rings often can reduce your O-ring costs substantially. At the same time, they may effect savings in machining time and inventory costs. Here's why:

Molded rubber O-rings are incompressible and therefore must be made to very close tolerances to allow perfect fit between the flanges. An O-ring too small in cross-section will not seal effectively . . . and an oversize O-ring will prevent flange contact.

Cork-and-rubber compositions, on the other hand, combine the compressibility of cork with the non-compressibility of straight rubber compounds. This compressibility can be controlled and compositions produced which are nearly as compressible as cork, or almost as incompressible as rubber. The percent of compression for cork-and-rubber rings may range, therefore, from 20% to 33%.

In some applications, the wider tolerances permissible with compressible lathe-cut rings may effect savings in machining time. In other cases, it may be possible to reduce inventories because one size of



cork-and-rubber ring may work where two or more rubber O-ring sizes might otherwise be required.

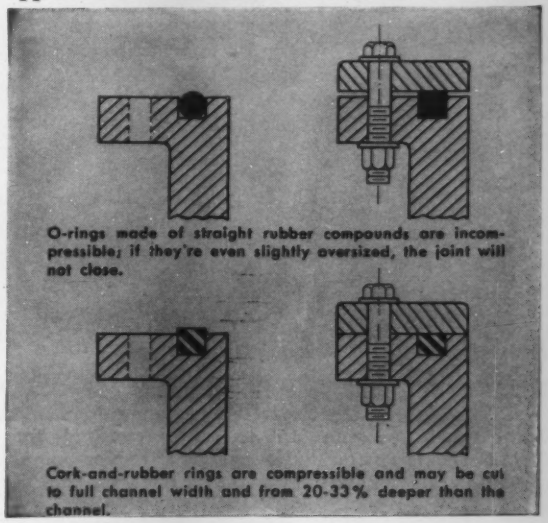
Armstrong Cork-and-Rubber Rings can be cut to fit existing channel dimensions (from ⅜" to 20" I.D.), with no change required in channel size or design.

Imperviousness

All lathe-cut Armstrong cork-and-rubber compositions are impervious. Their rubber binder encloses each cork particle in a continuous matrix. Cork-and-rubber can be used to seal high internal pressures. The upper and lower temperature limits vary with the different compositions and with the fluids to which they are exposed. In most cases, continuous operating temperatures should not exceed 300° F.

Solvent resistance

The solvent resistance of cork-and-rubber compositions is comparable to straight synthetic rubbers of corresponding base polymers. For example, cork-and-chloroprene-type synthetic rubber is normally used with lubricating oils, and for general purpose applications where some swell is desired or can be


O-rings made of straight rubber compounds are incompressible; if they're even slightly oversized, the joint will not close.
Cork-and-rubber rings are compressible and may be cut to full channel width and from 20-33% deeper than the channel.

tolerated. Cork-and-nitrile-type synthetic rubber provides good gasoline and aromatic-solvent resistance and has less tendency to swell or stick on metal surfaces. Cork-and-styrene-type synthetic rubber compounds, however, have very limited solvent resistance and should not be used for these purposes.

SEND FOR 24-PAGE GASKET MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Div., 7109 Dean St., Lancaster, Pa. For information on all Armstrong Gasket Materials, see Sweet's product design file.

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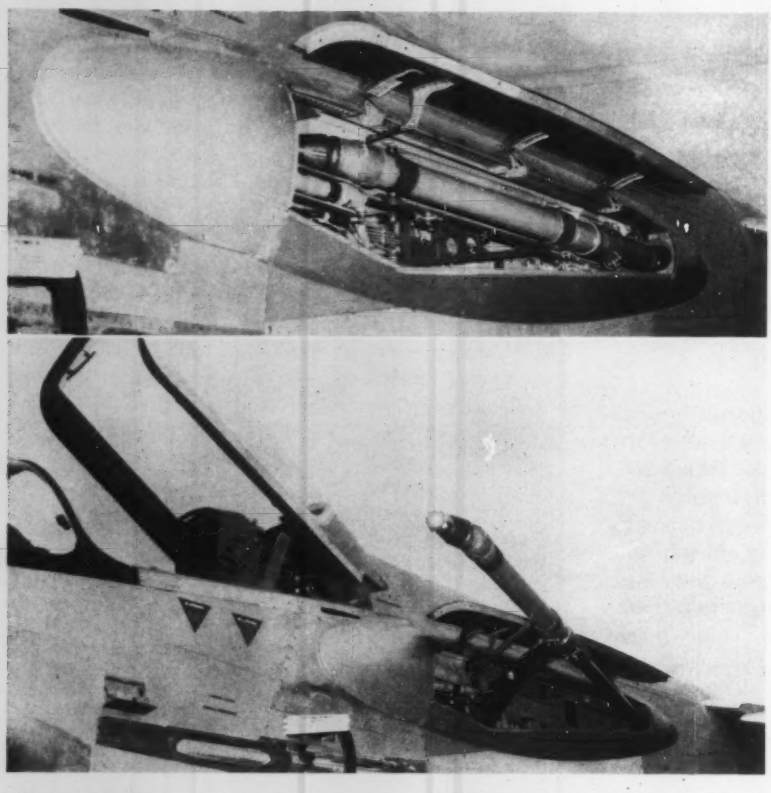


CLEARLY VISIBLE to the pilot during inflight refueling, the telescoping probe of the F8U-1 Crusader's refueling system rests in a detachable pod. Entire system, weighing 150 lb, can be removed from the plane in 20 minutes. Probe is hydraulically operated; moves out and forward 3½ ft on a swivel arm. The system was developed for the Navy by Chance Vought.

Mr. Sterling Fisher was responsible for work on the receiver.

Scientists associated with the program said that recent military developments, particularly the use of high-speed aircraft and missiles, had resulted in a dire need to increase radar range. Targets must be detected at great distances to allow time for defensive action. In addition to the effects of increased speed, jet bombers and missiles are very poor reflectors of radar signals compared to multiengined propeller-driven aircraft. It was indicated that the new methods would also be highly useful in certain phases of radio astronomy and in tracking satellites.

Dean Dunning declared that results of the new project assume even more significance due to another recent development by the Electronic Research Laboratories. He referred to the computing device developed at Columbia which is vital to a new air defense system. (MACHINE DESIGN, Aug. 22, 1957, Page 28).

The Columbia analog computer and its other components perform the basic tracking and computing required in an overall system which receives data from long-range radar units, tracks potential hostile planes, and then automatically directs interceptors to the oncoming target for the kill. The new defense system is the first operational ground control intercept system of the Air Force to work on the principle of electronic automation, furnishing signals which are automatically incorporated into the fire control system of the intercepting aircraft, guiding its flight to a terminal phase.

Topics

Flying saucer patent has been issued on a craft that consists of a flat circular wing with a cabin on top and a hole in the center, doughnut style. The inventor claims a saucer of his design will rise vertically, hover at any height from 5 to 50,000 ft and travel at supersonic speeds. He estimates that with "volume production," commuter-size saucers could sell for $8000, a price that would put one in (on?) practically every garage.

• • •

High heat resistance of natural rubber can now be matched by synthetic, and at a competitive price, according to three leading manufacturers. Production is now in the pilot stage, with commercial output two or three years off.

• • •

United States Science Academy has been proposed in a House of Representatives bill. Selected men and women between the ages of 17 and 22 would be trained as engineers and scientists, to serve as military officers and government employees. The bill provides for full tuition and allowance for students, and for buildings and equipment needed in their training.

• • •

Research and development cost $8.8 billion in the United States in 1956, according to Commonwealth Engineering Co. A projection of the trend in spending for this purpose indicates that the amount for 1957 will be $10.6 billion.

• • •

Twenty-hour work week, thanks to automation, is foreseen for the year 2000. This prediction was made recently by William Arnold, dean of education at the University of Pennsylvania, who warns that workers for the coming age of automation must be more broadly trained than today's workers. He told an assembly of vocational teachers that their work will largely determine whether there is "chaos or utopia" in 2000.

• • •

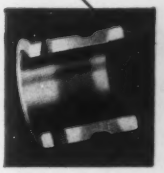
Half-and-half: Canopies of new parachutes are now being made of one-half signal cloth and one-half camouflage material. A crewman thus has means of signaling if he lands in an isolated region or concealing himself if he lands in enemy territory.

SEALMASTER'S EXCLUSIVE COMBINATION OF FEATURES ARE SETTING THE PACE!

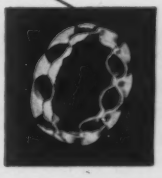
When you design, you design your products for maximum performance—and **Sealmaster** helps you attain it. **Sealmaster** Ball Bearing Units are engineered and manufactured with the same painstaking quality control you would insist on maintaining within your own plant. **Sealmaster's** exclusive combination of features assure you of maximum performance for each bearing. You'll want full information on how important these features are to you and your own product's performance.

LOCKING PIN & PERIMETER DIMPLE—prevents rotation of outer race and assures positive lubrication.

LABYRINTH-SEAL—keeps dust and dirt out and lubricant sealed in for long bearing life.

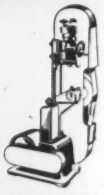


ZONE HARDENING—assures positive race to shaft holding power.

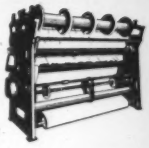


LANDRIDDEN BALL RETAINER—eliminates ball wear, traps grease and prevents churning.

...For Outstanding Bearing Performance



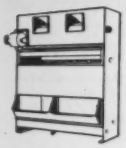
MACHINE TOOLS
SEALMASTER quality pays off where the trend is to continuous, fast, automatic equipment.



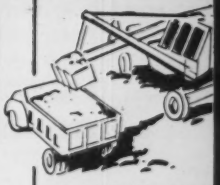
TEXTILE INDUSTRY
Clean, fast production is assured with SEALMASTER Bearings.

FARM MACHINERY
SEALMASTER Ball Bearing Units keep dust and dirt out, lubricant in—a feature Farm Machinery demands.

CONVEYORS
SEALMASTER Ball Bearing Units are featured by manufacturers of many types of conveyors.

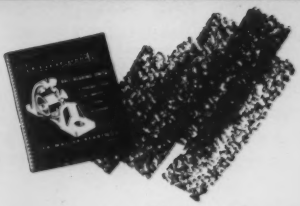


AIR CONDITIONING
Quiet, trouble-free performance is assured with SEALMASTER. Find out about new rubber mounted units.



CONSTRUCTION MACHINERY
SEALMASTER Ball Bearing Units provide the features for gruelling performance in construction and materials handling equipment.

SEALMASTER® BALL BEARING UNITS



Write for Bulletin 454

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO. 18 RIDGEWAY AVENUE, AURORA, ILL

Circle 408 on page 19

Edsel two-door hardtop and convertible models in the top Citation Series characterize the styling of Ford's new line.

Ford's Edsel Enters U. S. Market

DEARBORN, MICH.—Vertical front styling and self-adjusting brakes are among the engineering and styling features of America's newest car. The Edsel, under development since July, 1954, by the Edsel Div., Ford Motor Co., is being produced in four series comprising 18 models.

Styling features that characterize the car include the vertical grille, dual headlights, and long horizontal tail lights that blend into the luggage compartment deck. A slightly raised center section of the hood recalls styling of years past.

Front seats have been divided in a one-third, two-thirds arrangement with the one-third segment for the driver. Instrument cluster, under the steering wheel, features a new floating-drum type speedometer resembling a compass. "Teletouch" pushbutton transmission controls are mounted in the steering wheel hub.

Engine Specifications

	E-400 Ranger, Pacer, Wagons	E-475 Corsair, Citation
Type	90° V-8	90° V-8
No. cyls.	8	8
Bore & stroke (in.)	4.05 x 3.50	4.20 x 3.70
Displ. (cu in.)	361	410
Comp. Ratio	10.5 to 1	10.5 to 1
Bhp, max	303	345
Torque, max (lb-ft)	400 @ 2800	475 @ 2900
Combustion chamber	Angle wedge	Cylindrical wedge

Size

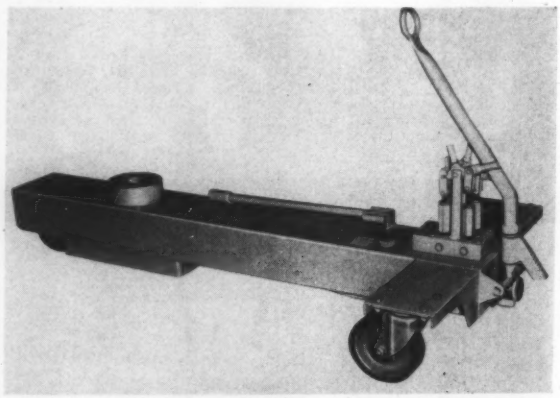
	Ranger Pacer	Corsair Citation	Station Wagons
Wheelbase (in.)	118	124	116
Length (in.)	213.1	218.8	205.4
Width (in.)	78.8	79.8	77.1
Height (in.)	56.4	56.8	58.8

Self-adjusting brakes are standard equipment on all Edsels and are claimed to eliminate the need for brake adjustments during the life of brake linings. Brake shoes adjust automatically when brakes are applied while the car is moving in reverse. Power brakes are optional on all models.

Two newly engineered V-8 engines featured in the Edsel line are designated E-400 and E-475 to indicate torque rating. Both have overhead valves, four-barrel carburetors, 18-mm sparkplugs, and 12 v electrical systems.

The E-400, available in the lower priced Ranger and Pacer series and the five station wagons, develops 303 hp; comes with standard, overdrive, or automatic transmission.

The larger E-475 engine in the Corsair and Citation models is rated at 345 hp and is available only with automatic transmission. It features a new three-stage cooling system which permits faster cold weather warm-up. A first stage restricts coolant circulation to cylinder heads and intake manifold. Second and third stages progress circulation to block and eventually to the radiator core.

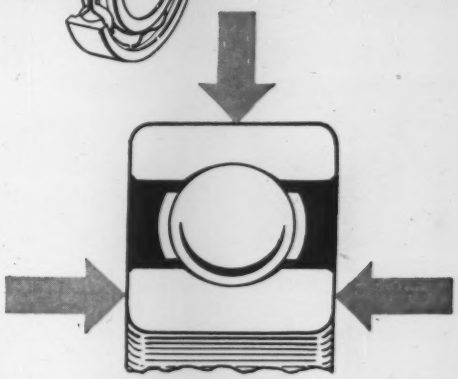


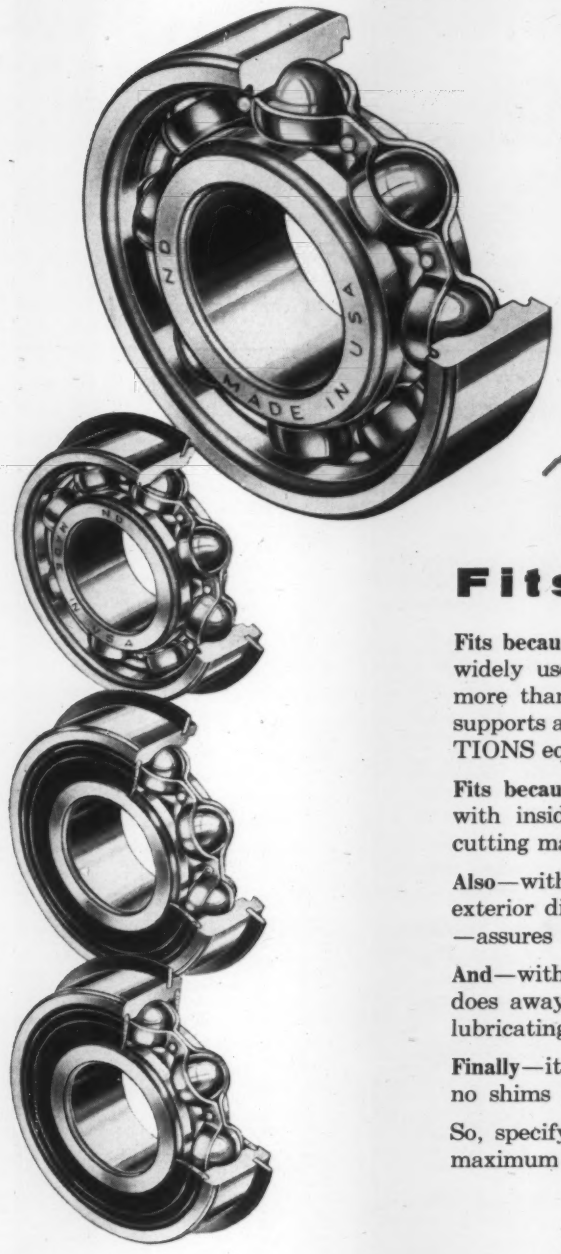
PORTABLE AIRCRAFT JACK with lifting capacity of 50 tons has been developed by Regent Jack Mfg. Co. Operating force at rated load is approximately 75-lb handle force. Lift, consisting of three rams and extension screw, is activated by double two-speed manually-operated pumps. Its overall height is 15.5 in.

FACTS

about

NEW DEPARTURE BALL BEARINGS





The Word *Versatile*

Fits Like A Glove!

Fits because—this basic New Departure ball bearing, more widely used than any other antifriction type, does much more than carry RADIAL loads—it locates the shaft it supports against THRUST LOADS FROM BOTH DIRECTIONS equally well!

Fits because—with a simple snap ring added, it does away with inside housing shoulders, simplifying mounting and cutting machining costs!

Also—with efficient Sentri-Seal added, without change in exterior dimensions, it eliminates a separate outside closure—assures protection from outside dirt!

And—with Sentri-Seals on both sides, this same basic bearing does away with all separate seals, eliminates all need for lubricating fittings—requires no attention for greasing!

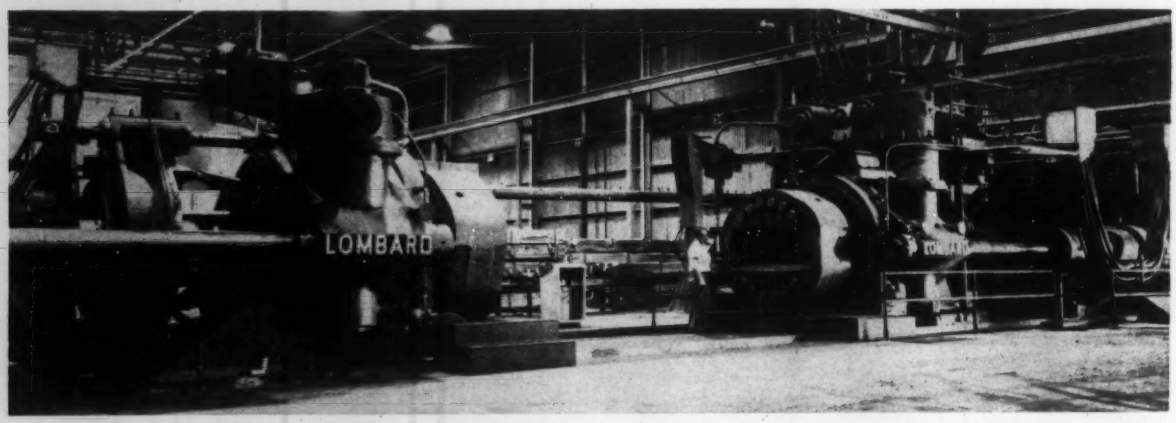
Finally—it is a long-lived, non-separable unit that calls for no shims or other devices for periodical adjustments.

So, specify New Departures of the type that assures you maximum application proficiency and economy.

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Circle 409 on page 19



STRETCH-STRAIGHTENING extrusions with diameters up to 29½ in. is the job of this 1500-ton stretcher made by the Lombard Corp. and installed in the Harvey Aluminum Div. of Harvey Machine Co. Gripping gap can be as small as 8 ft, as large as 113 ft. The overall weight of the stretcher is 1½ million lb.

Program Details Set for Mechanisms Conference

CLEVELAND, O.—Final details have been arranged for the program of the Fourth Mechanisms Conference to be held at Purdue University on October 14 and 15. The conference is sponsored jointly by the university's School of Mechanical Engineering and MACHINE DESIGN. Three previous conferences held at Purdue beginning in 1953 have been well attended and highly successful. For this reason, a much larger, more comprehensive program is planned for the 1957 Conference.

Registration is scheduled for 9 a. m. (Central Standard time) in the Main Hall, Memorial Union Building, on the Purdue campus, Lafayette, Ind. An advance registration form appears on Page 216 of this issue. Conference members will be welcomed at 10 a. m. by Prof. H. L. Solberg of Purdue and Colin Carmichael, editor of MACHINE DESIGN. Program for the technical session is:

Monday, Oct. 14

Registration: 9:00 a.m.
Main Hall

10:00 a.m.—SESSION 1
South Ballroom
Chairman: Prof. F. J. Bogardus, Purdue Univ.

Welcome and Orientation:
Prof. H. L. Solberg, Head, School of Mechanical Engineering, Purdue Univ.
Colin Carmichael, editor, MACHINE DESIGN

Mechanism Design in Germany
Kurt Hain, kinematic research scientist, Forschungsanstalt Fur Landwirtschaft, Braunschweig, Germany

A world-wide authority in his own right, Mr. Hain will summarize and interpret kinematic developments of the last ten years—particularly those in Germany and elsewhere on the Continent. Dimensional synthesis, with its convenient geometrical methods, and the "indirect" synthesis, for surveying a design to find the most suitable mechanism, will be interpreted. Also, analytical methods will be summarized, and current developments in spatial kinematics will be pointed out.

1:30 p.m.—SESSION 2A
South Ballroom
Chairman: L. F. Spector, associate editor, MACHINE DESIGN

Cam-Follower Equivalent Mechanisms
Prof. Harold A. Rothbart, The City College of New York

Movement of a cam follower is often difficult to establish analytically, especially if the follower is not a radial translating type. A useful concept for solving such problems is that of equivalent mechanisms. The method permits the analysis of any cams and followers moving in any manner, and it also provides a pictorial concept of the relative movement of the members. Professor Rothbart will present a compilation of equivalent mechanisms, corresponding to the large variety of cam-follower types, and show how they can be applied in typical design situations.

Design of a Constant-Load Cam
John A. Carlson, product development, Teletype Corp.

A growing problem is the design of cams to withstand loads imposed by high-speed operation. Design of cams for uniform loading is one approach for alleviating this problem. Dr. Carlson will present a method for calculating the contour of a cam intended to accelerate or decelerate a mechanism in which the main loads result from component inertia. Equations will be given for computing dimensionless cam coordinates for any friction coefficients.

A High-Speed Indexing Mechanism
Ray C. Johnson, senior design engineer, Eastman Kodak Co.

The problem—index a 3-in. diameter by ⅝-in. thick aluminum disk ten times per revolution at a maximum rate of 3000 complete stops and starts per minute. Mr. Johnson will describe a unique cam-follower system developed to answer this problem. His account will include a summary of practical factors such as materials selection, motion development, follower and cam proportions, and dynamic considerations.

1:30 p.m.—SESSION 2B
Chairman: Prof. C. L. Brown, Purdue Univ.

Kinematic Synthesis via Complex Numbers
Prof. Richard S. Hartenberg, Northwestern Univ.

A problem in the design of four-bar linkages is to find the length of members necessary to produce a prescribed result. This is one of the problems gradually yielding to solution by new techniques of kinematic synthesis. Dr. Hartenberg will present methods based upon use of complex numbers for determining lengths of links to satisfy velocity and acceleration specifications. His presentation will include a briefing on fundamental operations with complex numbers.

Kinematic Analysis via Complex Numbers
Prof. G. H. Martin, Michigan State Univ.

Although velocities and accelerations can be found quickest by graphical methods, mathematical analysis is advantageous under certain circumstances, as where greater accuracy is required. For the four-bar linkage, Dr. Martin will present general equations that give angular positions, velocities and accelerations of the connecting link and driven crank in terms of the angular position, velocity and acceleration of the driving crank. Method is based upon vector analysis and representation of vectors by complex numbers.

Alternate Four-Bar Mechanisms
Prof. A. S. Hall Jr., Purdue Univ.

Often, the application of a four-bar linkage requires that a certain relation between the two crank motions be maintained quite ac-

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Division of The Torrington Company
52 Norwood Street, Torrington, Connecticut

Circle 410 on page 19

curately but only for a small range of motion. Usually no one "best" design can be determined. Dr. Hall will briefly present a simple method for developing a number of designs producing nearly identical relationships between the crank displacements. From these the designer may choose on the basis of practical considerations other than motion specifications.

6:30 p.m.—BANQUET

North Ballroom

Toastmaster: B. L. Hummel, assoc. managing editor, MACHINE DESIGN

Unlocking Human Creativity

Dr. Richard W. Wallen, senior associate, Creelman Associates, Cleveland, O.

Techniques such as brainstorming are big aids in developing ideas and solving problems. But there are even more fundamental factors. Dr. Wallen, an authority in the field of psychology, will provide more insight into the creative process. Both organizational policy and personnel relationships determine that atmosphere which helps build a creative group of people. But helping people be more creative requires not only analysis of thought processes but also analysis of the social situations in which people work.

Tuesday, Oct. 15

8:30 a.m.—SESSION 3

South Ballroom

Chairman: W. S. Miller, associate editor, MACHINE DESIGN

Anticipating Dynamic Behavior

Prof. J. B. Hartman, Lehigh Univ.

Load and speed are hard to see in a design on paper. Moreover, all design proceeds with the aid of simplifying assumptions, which may or may not be safe. Dr. Hartman, an authority on the dynamics of machinery, will enumerate such factors of risk that should be anticipated in design, tell how to evaluate their significance, and suggest what to do about them.

Predicting Impact Forces

Ray C. Johnson, senior design engineer, Eastman Kodak Co.

In high-speed machinery, the designer usually wishes to move masses in as elegant a manner as possible. But for slow speeds or small masses, it may be dynamically acceptable and economically desirable to utilize mechanisms characterized by elastic collisions accompanied by impact forces. Mr. Johnson will present a method for predicting the likely range of the maximum impact force and the corresponding probable range of stress. The "true" answer is bracketed by two different approximations which lend themselves to relatively simple solution.

Linkages Using Racks and Pinions

Erwin P. Pollitt, senior research engineer, Armour Research Foundation

Linkages which contain a rack and meshing pinion can be employed with advantage where rotary oscillations with large amplitude must be produced. If the rack is directly attached to the driving crank pin and held in engagement with the pinion by a guide pivoting about the pinion shaft, the device is known as the inverted slider crank mechanism. Mr. Pollitt will present practical design information on this useful mechanism.

12:15 p.m.—LUNCHEON

North Ballroom

Toastmaster: Prof. A. S. Hall Jr., Purdue University

Education in the Orient

M. M. McClure, ass't director, Div. of Adult Education, Purdue Univ.

Defense Dept. Photos (Marine Corps)

TWIN FORKS on opposite sides of this vehicle speed up handling and delivery of Terrier missiles to ground-emplaced launchers. Forklifts move up, out, down, sideways to maneuver missiles into loading position. Designated Mk 30, Mod O, the Guided Missile Carrier Truck was built for the Marine Corps by Baker-Raulang Co. Overall length is 316 in.; width, 97 in.; wheelbase 157 in. Powered by a six-cylinder, 196-hp Continental engine, the truck carries a 10,700-lb load at 27 mph and tows a four-wheel launcher.

1:30 p.m.—SESSION 4

South Ballroom

Chairman: Prof. R. S. Hartenberg, Northwestern Univ.

The Double-Crank Linkage

Kurt Hain, kinematic research scientist, Forschungsanstalt Fur Landwirtschaft, Braunschweig, Germany

The double-crank or drag linkage is a four-bar linkage with two fully rotating cranks. It serves to transform uniformly rotating motions into irregularly rotating motions. Hence, it is ideally suited for placing in series with other mechanisms whose velocity and acceleration conditions are to be transformed from ones produced from, for example, a uniformly rotating input. Mr. Hain will present comprehensive design data on the double-crank linkage and how it can be applied in the synthesis of mechanisms or the improvement of motions from other common mechanisms.

Dwell Linkages vs. Cams

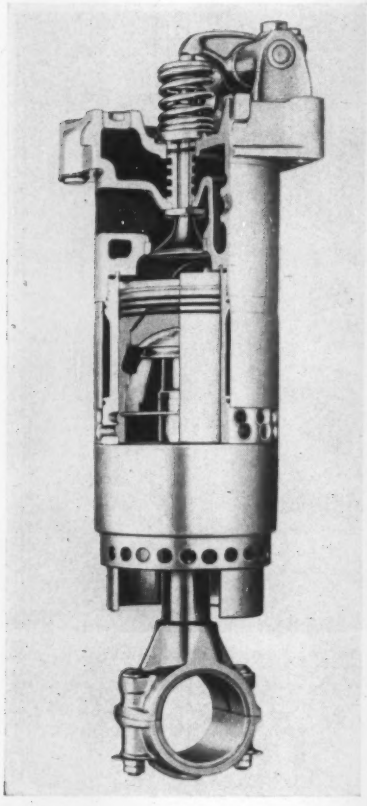
Prof. Thomas P. Goodman, Massachusetts Institute of Technology

This perennial debate is generally conducted on a "qualitative" basis, too often with no conclusive supporting evidence. Professor Goodman will present evidence in the form of a comparison of specific design of linkages and cams. He will compare the velocity and acceleration characteristics, as well as "jerk," the first derivative of acceleration, and discuss the pros and cons of dwell linkages as substitutes for cams.

General Discussion

During this final period Conference members will be invited to present any points of view or solutions to problems they have developed in any of the subject areas covered by the discussions. Questions or comments on other mechanism problems will also be welcomed.

A room reservation form appears with the conference registration form on Page 216 of this issue. Or, for complete information, write to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.



MUSHROOM ROD AND PISTON, claimed to be new in the design of diesel engines, uses a half-ball and socket coupling to replace conventional wrist pin. Hollow connecting rod carries oil from crankcase to network of oil grooves in top side of the rod bearing. Harnischfeger Corp. designed the assembly for its line of two-cycle diesels. Advantages claimed: Reduced carbon accumulation, longer life for both piston and rings, and improved oil control.

Four-Square Iron Parts To Cut Electric Motor Losses, Noise

Cube Texture Crystal Pattern Favors Four-Way Magnetism

SCHENECTADY, N. Y.—Lower energy losses and reduced noise in many types of electrical equipment can be expected from the use of a new silicon iron developed by General Electric Co. Termed "four-square," the new material is doubly-oriented sheet easily mag-

(*Please turn to Page 22*)

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- Inherently accurate speed regulation.
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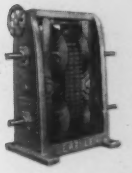
- Infinitely variable speeds—sensitive and responsive to critical control—manual or automatic.
- Adaptability to the precise needs of the specific machine or process.

SPEED RANGES TO 20:1 RATINGS TO 60 H.P.

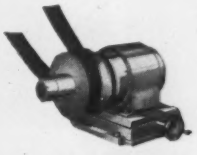
Horizontal Open V/S Transmission

Horizontal Enclosed V/S Transmission

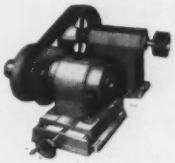


Vertical Open V/S Transmission

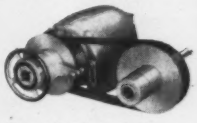
Vertical Enclosed V/S Transmission



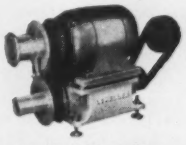
Variable Pulley



Variable Pulley with Counter Shaft



Combination Pulleys



Combination Pulleys with Counter Shaft

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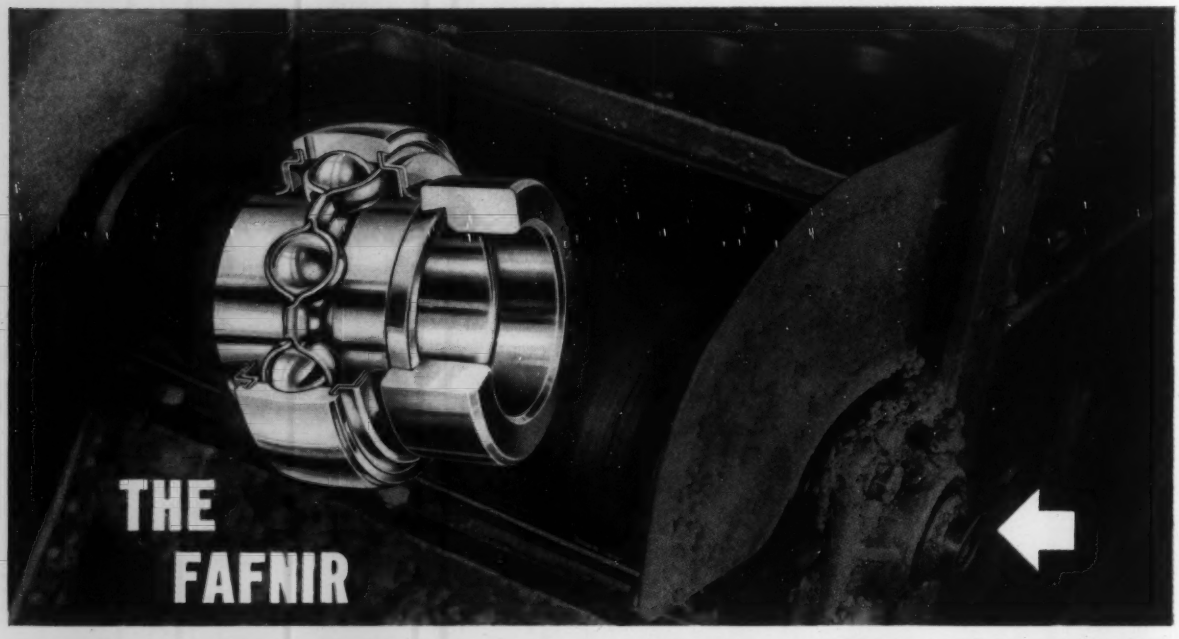


PLYA-SEAL WIDE INNER RING BALL BEARING

Designed expressly for slow speed applications and wet or dirty operating conditions

New Fafnir Plya-Seal Wide Inner Ring Ball Bearings are a combination of two outstanding bearing developments. The most effective seal ever devised for retention of grease and protection against contamination, plus the famous Fafnir self-locking collar, for cost-cutting, twist-of-the-wrist bearing installation. This combination of features offers you several advantages . . .

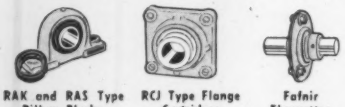
Best protection yet against dirt, dust, steam, water, lint, other contaminants on slow to moderate speed applications. Contact-type, Plya-Seals seal out abrasive or corrosive material, seal in factory prepacked lubricant.

Less Maintenance — In many applications, non-relubricatable bearings may be used. They require virtually no maintenance time or expense. In other applications, where bearings receive hard or constant use, relubricatable types are available. They require only occasional greasing, even under severe conditions.

Longer Service life — Plya-Seals protect against premature bearing wear or failure. Contaminants cannot damage balls or races; sealed-in lubricant ensures against bearing "running dry".

Simplified Designing — Bearing housings may be designed without incorporating separate housing seals. Plya-Seals provide full protection; make possible simplified, less costly, more compact housings.

Power Transmission Units incorporating new Fafnir Plya-Seal Wide Inner Ring Bearing



RAK and RAS Type Pillow Blocks | RCJ Type Flange Cartridges | Fafnir Flangettes

Write for bulletin containing complete specifications on Fafnir Plya-Seal Wide Inner Ring Ball Bearings and Power Transmission Units. The Fafnir Bearing Company, New Britain, Conn.

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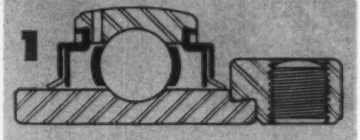
MOST COMPLETE LINE IN AMERICA



PLYA-SEALS

As incorporated in the Fafnir Plya-Seal Wide Inner Ring Ball Bearing, the Fafnir Plya-Seal consists of a synthetic rubber-impregnated fabric sealing washer sandwiched between dished steel plates. Seal flares out, maintaining constant contact with ground outside diameter of inner ring. Years of service have proven Plya-Seals the most effective seal ever developed for ball bearings.

SELF-LOCKING COLLAR

Originated by Fafnir, this famous development has cut costs and simplified assembly throughout industry. Bearings slip onto shaft; are locked securely with simple twist of self-locking collar. No need for lock nuts, shoulders, sleeves, washers, or adapters. Positive binding action increases with use.

Circle 412 on page 19

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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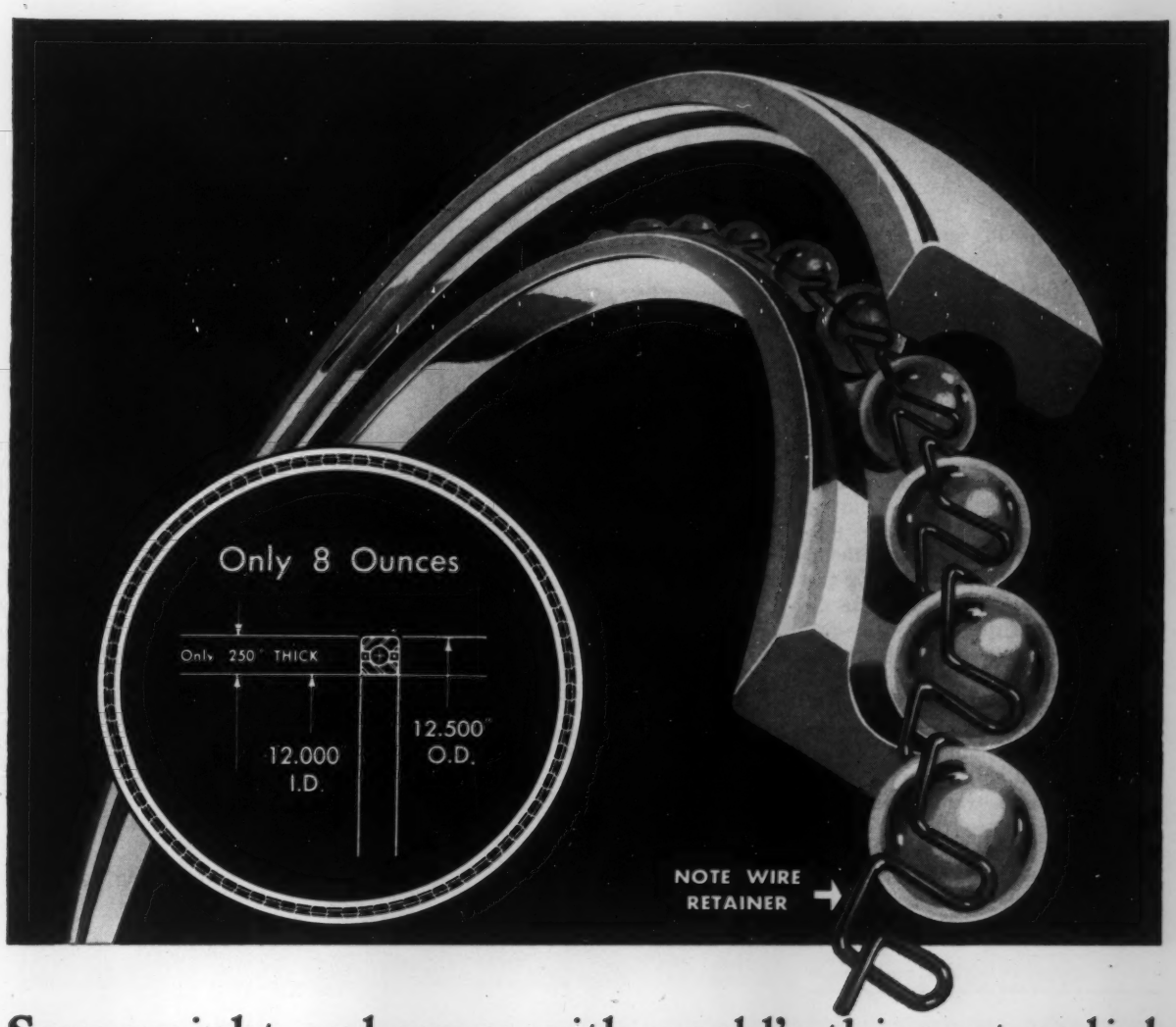


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

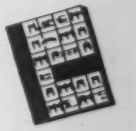
The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".



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Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.

Circle 413 on page 19

(*Continued from Page* 15)

netized in four directions.

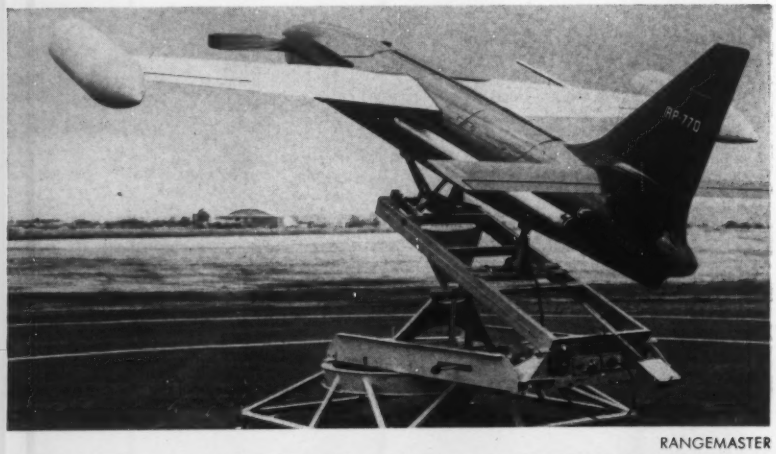
Orientation in silicon iron is achieved by aligning the crystalline grains in finished sheet material. The grains serve as conductors of magnetic lines of force.

Two-directional silicon alloy sheet, having grains oriented parallel to the sheet edges, was first accomplished more than 20 years ago. Used extensively today in transformers and motors, it eliminates nine-tenths of the core losses due to random orientation in unalloyed iron.

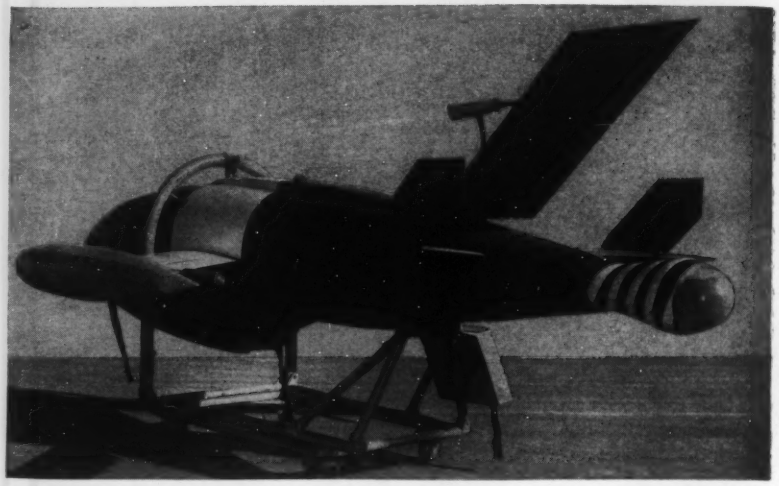
The doubly-oriented "four-square" effect is produced by a kind of alignment known as "cube texture." This arrangement achieves good magnetic properties along the sheet and also in two opposite directions across the sheet.

Rigid control of the internal structure of the metal during all steps of processing is the secret of the GE process. The silicon iron raw material is similar in composition to typical soft magnetic sheet used in present transformers and motors.

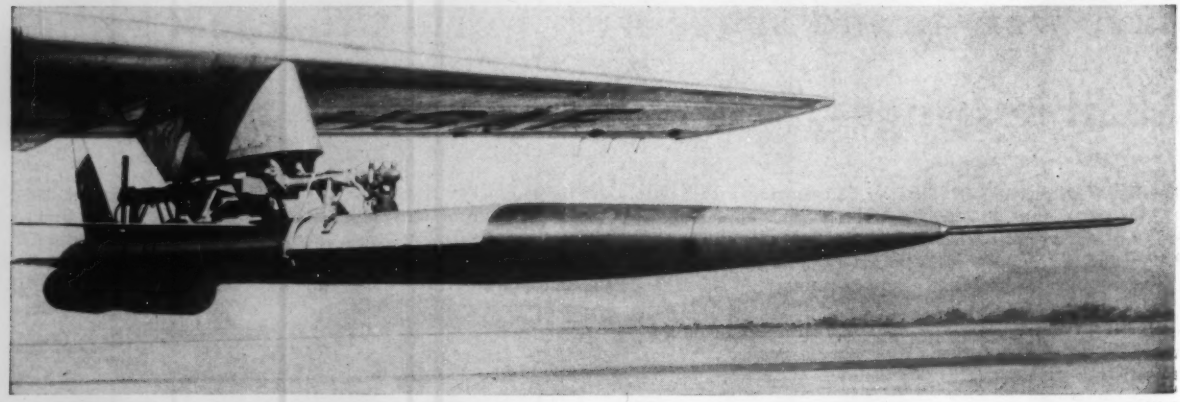
GE expects to make "four-square" magnetic sheet in commercial quantities, at reasonable prices, but can't say when.



RANGEMASTER

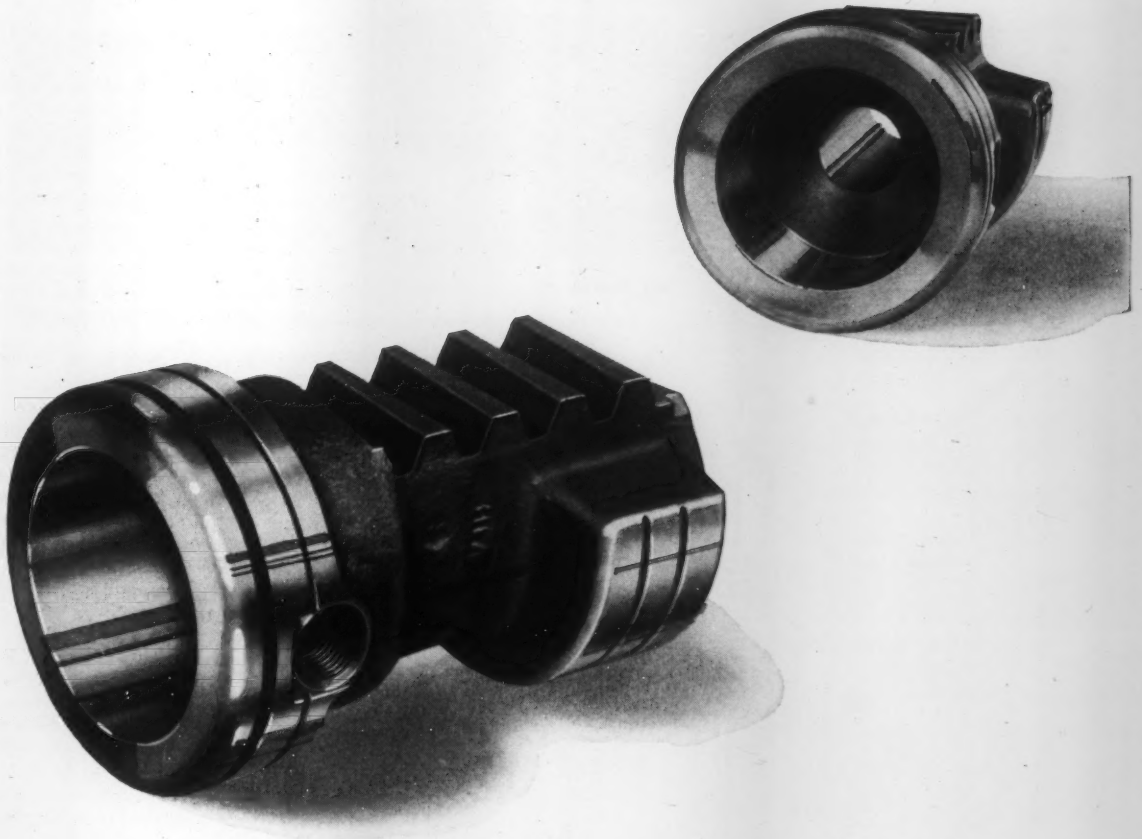


FIREBEE



XQ-4

EVASIVE TARGETS for aircraft and missile evaluation are provided by these high-speed, radar-controlled drones. "Rangemaster," developed by Radioplane Co., features fiber glass construction and free-turbine turboprop engine. It will climb to 48,000 ft, fly at speeds in excess of 400 mph, carry a payload of photographic and television scoring cameras. Versatile "Firebee," produced by Ryan Aeronautical Co., simulates much larger aircraft by use of special radar and infrared auxiliary units. Radar reflector in tailcone of Firebee shown here permits ground search units to "see" the drone at much greater distances. Other Firebees are equipped with infrared lights and flares to attract heat-seeking missiles. Top speed is about 600 mph. The recently announced supersonic XQ-4, developed by Radioplane Co., is turbo-jet powered, performs at a ceiling of 60,000 ft. It has wing span of 12 ft, length of 35 ft. Since drones are complex and costly, they have recovery parachutes.



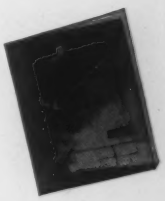
TOOL LIFE SOARED FROM 25 TO 750 PIECES WITH ARISTOLOY LEADED

Counterboring 8 lb. forging was costly for large steering gear manufacturer

Excessive tool breakage was running into hundreds of dollars per month for a large automobile parts manufacturer. On 2.17" ID counterboring operation of this forging made from A.I.S.I. 5120, chips were long and continuous. They wrapped around the tool, fouling it and causing premature tool failure. Tool life averaged only 25 pieces per tool.

A change to Leaded Aristoloy 5117 brought about an immediate improvement not only in tool life but in increased production and vastly improved finish. Tool life was upped to 750 pieces per tool. Spindle speed was increased from 113 to 239 R.P.M. and feed from .007 to .0134 I.P.R.

If you have a problem involving counterboring or deep hole drilling, call your nearest Copperweld district office. We will be glad to have a field metallurgist, experienced in application of lead treated steels, work with you.



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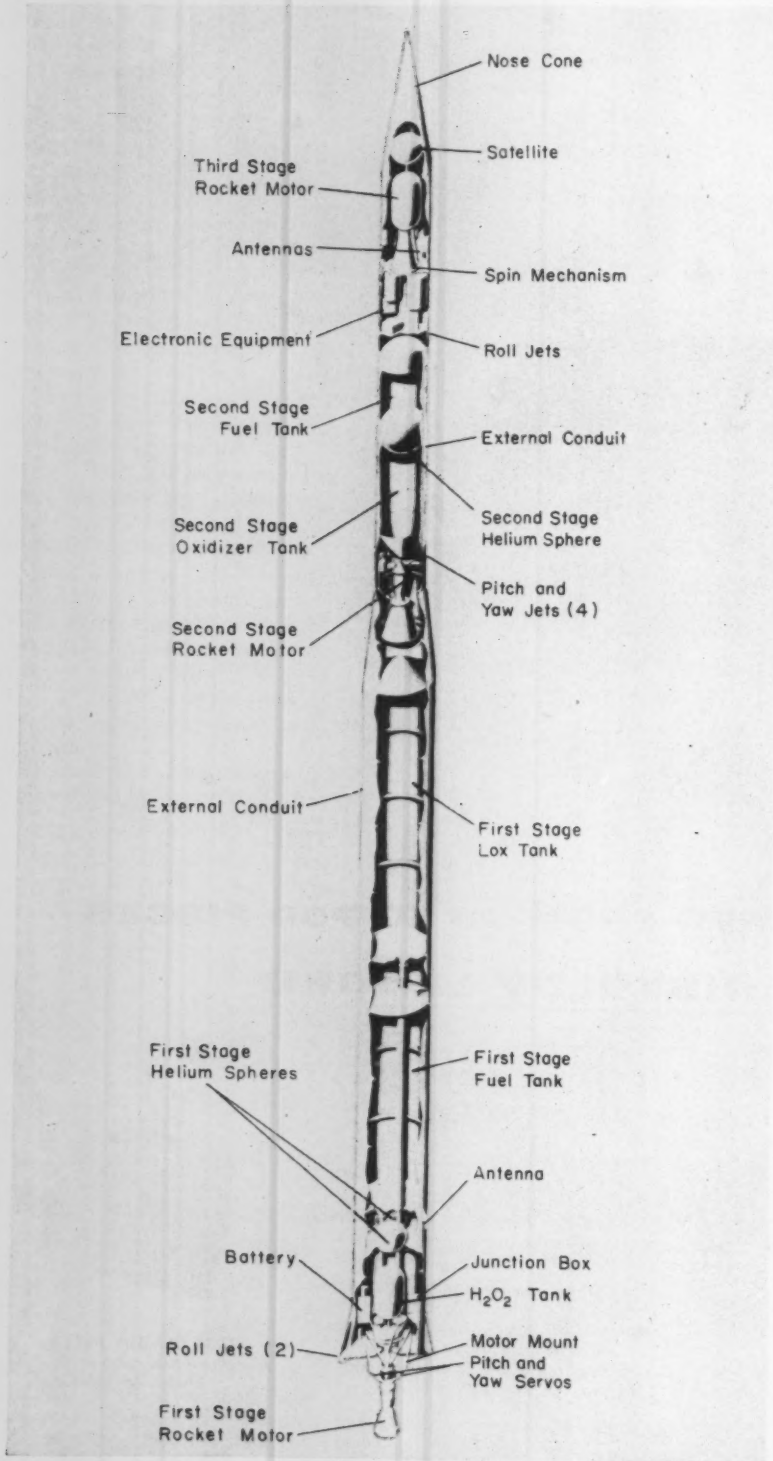


CLOSER LOOK AT VANGUARD is afforded by this drawing, the first officially released to show the satellite rocket's configuration. The vehicle is about 72 ft long, 45 in. in diameter, weighs 22,000 lb. The first and second stages have gimbal-mounted engines which can tilt to alter flight.

Metals Matters

Quick-frozen aluminum sheet, 10 by 46 ft, was shipped from Alcoa's Davenport, Iowa, works to Douglas Aircraft Co. in California. Refrigeration of the aluminum, accomplished with dry ice, was necessary to postpone normal age-hardening of the material until its arrival at the Douglas plant. Sheets are fabricated into sections for DC-8 jet airliner wings.

• • •

New super steel made by Midvale-Heppenstall Co. is claimed to have superior chemical and mechanical properties, improved workability and ingot soundness. It is produced by the Mid-Vac process of melting steel through the use of consumable electrodes in a vacuum. A high degree of cleanliness is achieved through removal of nonmetallic inclusions and excess gases.

• • •

Nonmagnetic thermostat metal, Truflex S125, is unmoved by magnetic forces up to 250 oersteds. In electrical instruments, where ambient compensation and other thermal functions provided by thermostat metal elements are necessary, the new metal will not be influenced by and will not cause disturbances in magnetic fields. Truflex S125 was developed by the General Plate Div. of Metals & Controls Corp.

• • •

Simple K-factor tester to measure specific thermal conductivity of materials meets ASTM requirements, is quick and convenient to use and low in cost. The tester, made by Tatnall Measuring Systems Co., consists of a portable hot plate unit, a cold bath and a relay rack. Material up to 1.25 in. thick can be accommodated, and operating temperature can be as high as 600 F. Three cold bath models operate at room temperature down to −100 F.

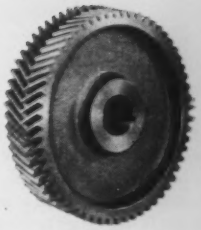
• • •

Easily welded aluminum plate is being rolled by Alcoa for marine and heavy-duty structural uses. The company reports that the new alloy 5456 has the highest mechanical properties available in the nonheat-treatable alloys. It is produced in O and H321 tempers; typical properties of the latter are 51,000 psi tensile strength, 37,000 psi yield strength, and 16 per cent elongation.

Wherever Power is on the move...

INDUSTRY DEPENDS ON ILLINOIS GEAR

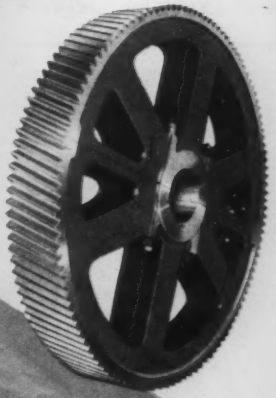
Throughout the world . . . wherever power is on the move . . . ILLINOIS GEARS are *delivering this power* dependably year in and year out.

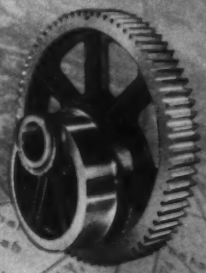


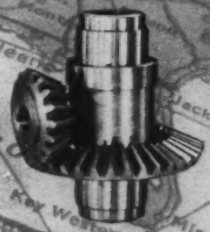
Whether it is in machine tools, steel mills, cement mills, paper mills, chemical plants, construction equipment . . . machinery of any kind . . . this dependability, proven by performance, means true economy that has resulted in enduring customer satisfaction.

When you need gears—remember this: ILLINOIS GEAR manufactures *the most complete line of quality gears in the world.*

You can specify and buy ILLINOIS GEARS *with confidence and assurance* that they will more than satisfy your most exacting requirements.







Look for this mark ILG® the symbol on finer gears

ILLINOIS GEARS Reg. U.S. Pat. Off.

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

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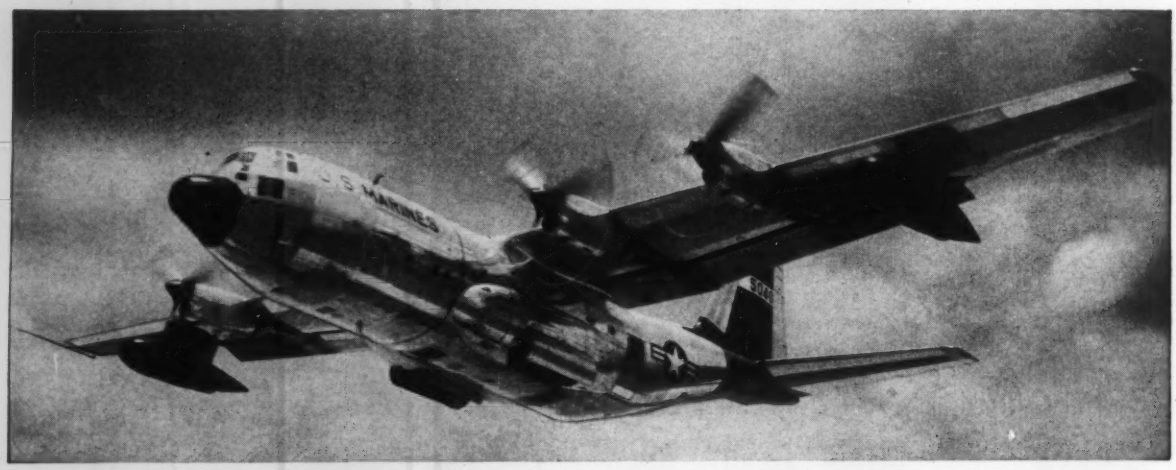
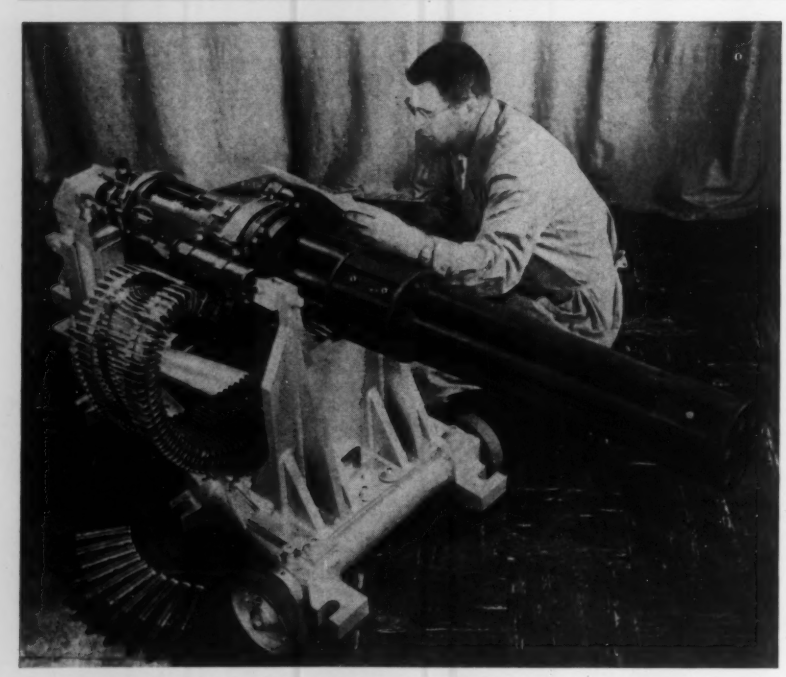


FLYING REFRESHER FOR THIRSTY JETS, Lockheed's C-130 Hercules is being tested for the first time as an aerial tanker. Pods attached to wings contain motor-driven reels and drogues for refueling fighter aircraft in flight. Hercules is America's first production prop-jet, will fly at speeds in excess of 370 mph and at altitudes ranging to 40,000 ft. Four Allison T56 engines produce 15,000 hp. Lockheed recently announced testing of a "B" version of the C-130. The new model will have more powerful engines, higher take-off weight, additional fuel tanks, stronger landing gear and four-bladed propellers. The plane has been valued as a general utility air-freighter for tactical support because of its ability to take off and land from short, hastily prepared landing strips. Increased range and payload would enable it to provide logistic support.



LARGE-CALIBRE VERSION of R. J. Gatling's 1862 invention is being tested as armament for 1957 aircraft *(Machine Design,* Aug. 22, 1957, Page 31). This 30-mm model, Vulcan T212, is an enlargement of the 20-mm Gatling gun, Vulcan T171, currently in use on the Air Force's Lockheed F-104 Starfighter. Both guns fire 6000 rounds per minute, but the 30-mm weapon provides three times the striking power of its 20-mm predecessor. Both versions mount six rotating barrels from a central feed and firing housing; can be operated electrically or hydraulically; were made by GE.

Progress Announced in Program Aimed at Launching Vanguard

Test Launchings Successful; More To Precede Real Thing

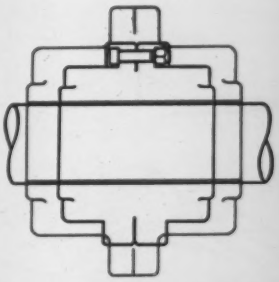
WASHINGTON, D. C.—Two successful test launchings to date and plans for more have been announced by the Department of Defense in the program to develop the earth satellite vehicle, Vanguard.

A Martin Viking was the vehicle in the first test, Dec. 8, 1956. The second test occurred May 1, 1957 and used a two-stage rocket consisting of the Viking and the proposed third stage of Vanguard.

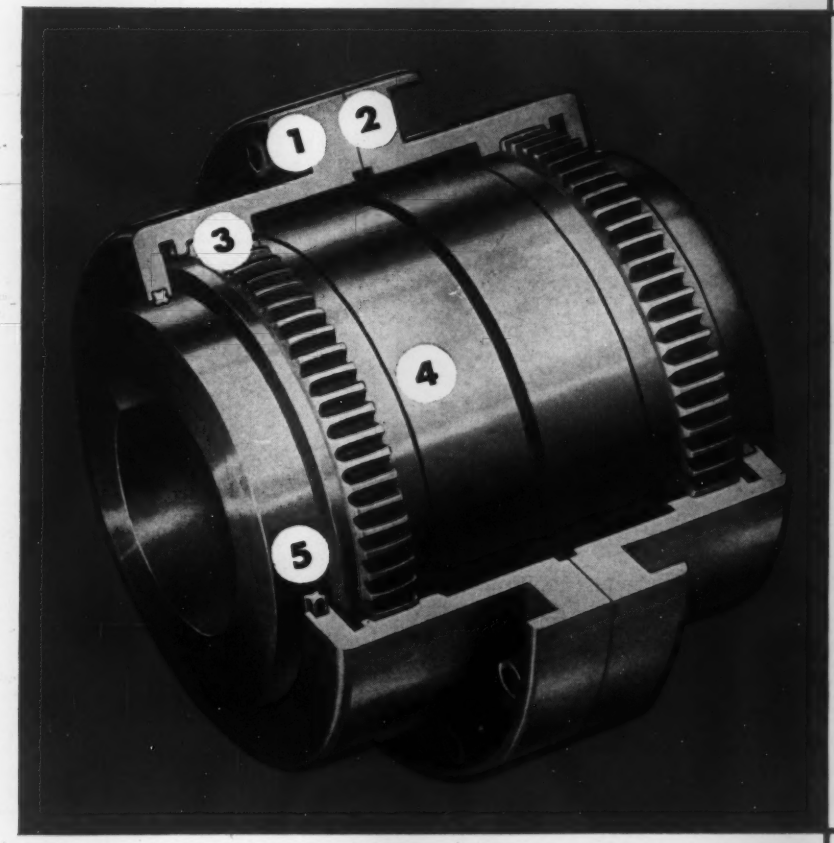
The third test, which may occur this month, will involve the complete Vanguard in which the second and third stages will be dummy. If the third test is successful, four test firings with complete three-stage Vanguards are planned.

Each of the complete three-stage tests may carry a test payload consisting of a magnesium sphere 6.4 in. in diameter, weighing about 4 lb. The spheres will carry miniature radio transmitters by which

Compactness - -
it's the big difference in geared flexible couplings



Link-Belt geared couplings (black) are smaller, lighter, yet highly capable—provide dependable performance plus savings in space and cost.



These features assure coupling reliability:

1. **SOCKET HEAD FLANGE BOLTS** of hardened steel with ground body securely join housing halves. Locknuts prevent loosening in operation.
2. **FIBER GASKET** fits tightly between flanges. Lubricant can't escape.
3. **PRECISION-CUT** gear teeth have controlled clearance to allow for normal misalignment—minimum backlash.
4. **ALL-STEEL CONSTRUCTION** with properly proportioned parts assures sturdiness, long life operation.
5. **QUAD-RING SEALS** are exceptionally effective in retaining the lubricant. Gearing is always submerged in oil, assuring long, trouble-free operation.

That's why LINK-BELT geared flexible couplings transmit more hp per coupling dollar

COMPACTNESS and high load capacity make Link-Belt geared flexible couplings your best answer for economical power transmission. Size for size, they will accommodate larger, more powerful shafts than other flexible couplings.

These couplings are all-steel and accurately machined for dependability and long life. Hardened flange bolts are ground for close fit. Socket type bolt heads require less of the coupling diameter to be used in the flange—more is available for larger gears and larger shafts.

Compact and rugged — these couplings offer exceptional durability to cope with shock, pulsation, reversing loads and misalignment. For horsepower ratings and dimensions, contact your Link-Belt office. Or write for Folder 2775.

LINK-BELT

GEARED FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

14,485-A

Circle 416 on page 19

A TALENT FOR INVENTION: Leroy® Lettering Equipment—a K&E development—insures perfect neatness and uniformity, yet it is simple to operate and requires no special skill or training. One man can start a job and another finish it without any variation in lettering.

This K&E equipment comprises three basic, precision engineered parts: Leroy template, Leroy pen and Leroy scriber. Capitals, lower case, numerals, vertical or forward slanting letters can be drawn from a *single* template—an *exclusive* K&E feature. You can buy templates, pens, and scribers separately or in convenient sets.

Leroy templates offer a variety of alphabets, sizes and graphic symbols. Electrical, mathematical, mapping, geological and other symbol templates are available. Templates, with words or phrases that are frequently repeated, as well as templates with your own symbols, trade marks or designs, can be made to your order.

To save time and money in your drafting room specify K&E Leroy® Lettering Equipment. For other drafting or engineering equipment and materials also look to Keuffel & Esser Co.—your "Partners in Creating"—who have served engineering for 90 years.

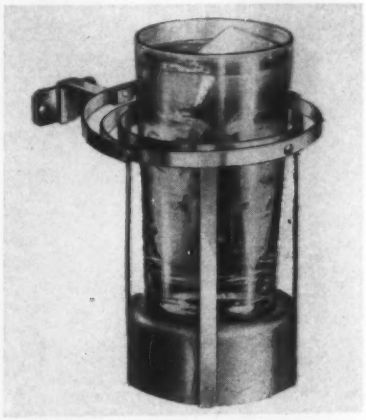
KEUFFEL & ESSER CO. New York, Hoboken, N.J., Detroit, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle, Montreal.

News Roundup

tracking stations will obtain data to determine velocities of the spheres before and after ejection from the last stages.

As test objectives are reached in the step-by-step program, fewer test instruments will be required in rockets fired. Consequent decrease in weight will permit increase in rocket velocity. An orbiting satellite is theoretically possible, but not an objective, in the test portions of the program.

Final Vanguard objective is the lauching of an instrumented sphere 20 in. in diameter sometime during the International Geophysical Year. All firings will occur at Patrick Air Force Base, Cape Canaveral, Fla.



EVERY DROP TO DRINK, and none to spill, is assured by a gimbals-type bottle or glass holder. The tip-proof Drink Buoy, designed by Ami Co. Inc. for use on board boats, yachts, trains, planes and ocean liners, holds drinks steady against pitching and rolling motions. It is made in a wall-mounted model as shown and a table model.

Applying standards for the most effective use of manpower and machine power will be considered at the Sixth Annual Meeting of the Standards Engineers Society, to be held at Hotel Commodore, New York, September 23-25.

Seven sessions will offer discussions of effective use of standards. The program includes discussions of management's problems with

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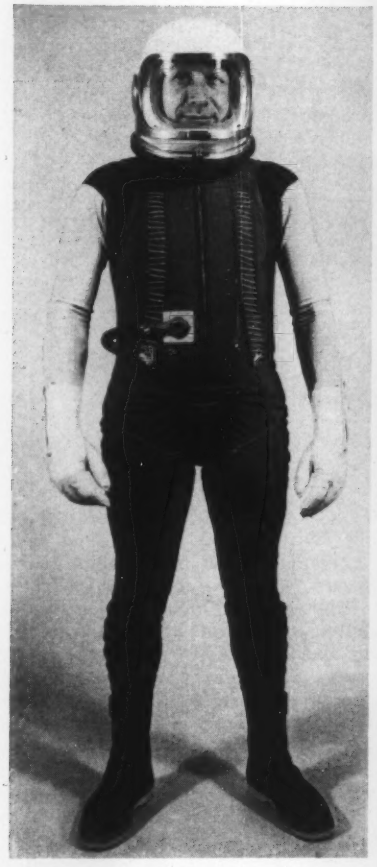
standards, preparation of standards, sources of information, making standards information available, co-operation between standards and other departments, reliability, and cost reduction.



SUPERSONIC SUIT under development for Air Force pilots provides greater safety, more mobility and increased comfort than existing flight gear. Some advantages of the new outfit are: It is lightweight; it floats a ditched pilot face up (even the boots float); the helmet permits turning the head 90 degrees in either direction; the two-part gloves pressurize the backs of the pilot's hands, but not his fingers.

Multiple V-belt drives used primarily for power transmission in industrial applications are the subject of a proposed American Standard, ASA B55.1-195X, currently be-

SELECT-O-PUSH SAVES SPACE WITHOUT SACRIFICING FUNCTION!

One unit, the Westinghouse Select-O-Push, combines a pushbutton and selector switch to do the job normally requiring two assemblies. It cuts panel-front space need by half.

When wired with a standard double-pole contact it becomes versatile in limited space, freeing valuable enclosure area.

The same attention to detail built into all Westinghouse controls applies to the Select-O-Push. It functions excellently where moisture threatens. Tight-fitting gaskets, stainless steel shafts, precision milling—all help keep out harmful liquids.

A Guide to Control (B-7022) will tell you more about Oil-Tite* controls. The new 72-page *Push-button Guide* (B-6749) will give you information on the complete line. Write to Westinghouse, Box 868, Pittsburgh 30, Pa. *Trade-Mark J-30254

YOU CAN BE SURE...IF IT'S
Westinghouse

Circle 418 on page 19

Special
BALLS

. . in experimental and production quantities—

For

• HIGH TEMPERATURES
• CORROSION RESISTANCE
• NON-MAGNETIC PROPERTIES
. . other special requirements

ALL SIZES, standard and special, from 1/64" to 12" or more, depending on material.

ALL MATERIALS, including special ferrous and non-ferrous alloys, plastics, ceramics, carbides, synthetic sapphire.

MODIFIED BALLS, with slots, undercuts, tapped holes, etc.

We also provide
PRODUCTION SERVICE
on spherical and toroidal surfaces.

Write for quotation and descriptive literature.

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PRECISION BALLS AND
SPECIAL ANTI-FRICTION BEARINGS

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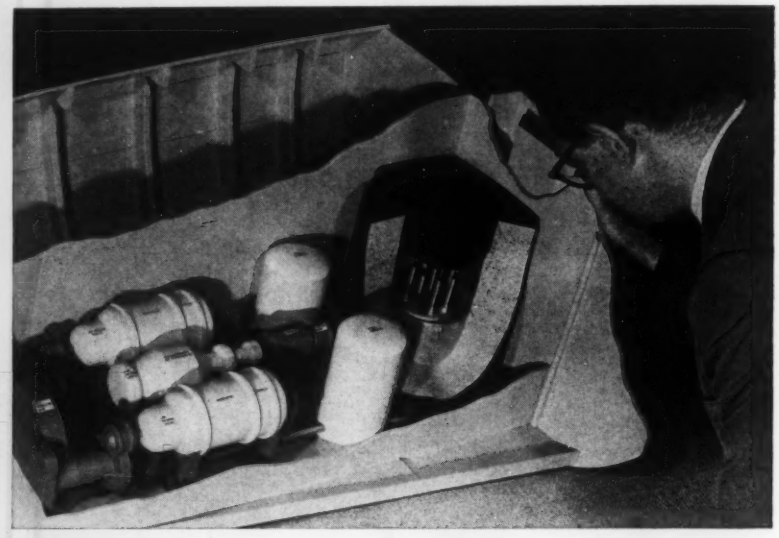
ing circulated for criticism and comment. Sponsors are the American Society of Mechanical Engineers and the National Machine Tool Builders Association. The Standard covers dimensions, recommended installation practice, horsepower ratings and service factors. Free copies are available, on letterhead request, from Frank Philippbar, Standards Dept. ASME, 29 West 39th St., New 18, N. Y.



NUCLEAR REACTORS FOR MERCHANT SHIPS may make engine rooms look like this as early as five years from now, according to Theodore Jarvis, director of nuclear engineering, Ford Instrument Co. The gas-cooled reactor and closed-cycle turbine may be the accepted propulsion. Advantages of this system are: Low cost of installation and operation, high thermal efficiency independent of power output, compactness, and light weight. Safety and simplicity, also claimed for the closed-cycle system, are attributed to the use of an inert gas as the working medium, the total absence of water, and a minimum of moving parts. Closed cycle and inert gas avoid corrosion.

Survey Finds Engineers' Pay Up 21 Per Cent, 1952 to 1956

Chemists and Teachers Show Biggest Gains; Federals Trail

WASHINGTON, D. C.—Largest gains in the total earnings of all professional engineers over the period 1952-1956 have been made by groups classed as young engineers, chemical engineers, and engineers in education. Smallest gains in the same period were made by engineers in Federal agencies.

These are findings from the latest *Professional Engineers' Income and Salary Survey* published by the National Society of Professional Engineers. The survey is an analysis of 17,000 questionnaires returned from registered professional engineers in all technical branches.

The survey shows an increase of 21 per cent in the median earnings of engineers during 1952-1956. The median salary and income figure for the engineers responding in 1956 was $9400. It was $7850 in 1952.

According to the survey, median earnings in 1956 for electrical engineers was $9460; for mechanicals, $9780.

Competition among employers for recently graduated engineers is reflected in the percentage increase in earnings for this group. Engineers at a pre-professional level were found to have had an increase in earnings of 28 per cent from

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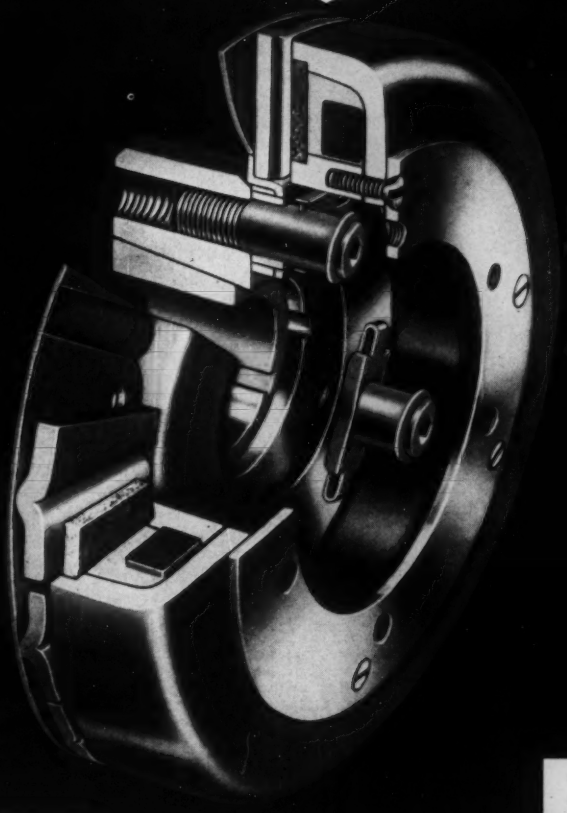
THEY'RE NEW!



THEY CUT MAINTENANCE COSTS!

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SMOOTH, EASILY CONTROLLED ENGAGEMENT

WIDE RANGE OF SIZES AND CAPACITIES

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Centrifugal Castings for Industry

Does your **Cylindrical** *problem call for a* **Centrifugal** *solution?*

If your product plans call for hollow cylindrical parts, give some thought to these facts. Manufacturers who had never seriously considered cast parts before are discovering important advantages in Sandusky centrifugal castings.

They're getting exceptional resistance to heat, corrosion, abrasion and stress, through the use of special alloys cast centrifugally . . . in diameters from 7" to 54", and lengths to 33 feet depending on diameter . . . and specially machined to specifications.

How can our versatile staff and facilities help you? Tell us your product requirements. Let us explore your ideas. Perhaps we can help solve your cylindrical problems through the vast foundry experience, metallurgical research and machining skills our 46 years offer.

Your request will bring more information promptly . . . or, if you prefer, a personal call by one of our engineers. Sandusky Foundry and Machine Company—Sandusky, Ohio.

Sandusky centrifugal castings offer you 4 important advantages:

1. ***SUPERIOR STRENGTH***—through non-directional mechanical properties
2. ***BETTER QUALITY***—machined castings are porosity-free
3. ***UNIFORM SOUNDNESS***—harmful inclusions are forced out by spinning motion
4. ***JOB-READY FINISHED CASTING***—reach you machined exactly to your specifications . . . eliminating extra costs from rejects, down-time, loss of production, etc.

Sandusky Centrifugal Castings

Stainless steels—plain carbon and low alloy steels—wide variety of copper base compositions

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1952-1956, a higher increase than was noted in any of the other grades.

Statistical breakdown of over-all earnings shows that 90 per cent of all engineers who replied to the survey earned at least $6390 in 1956, compared to $5570 for 90 per cent in 1954.

On a regional basis, the 1956 survey shows that engineers in the East Coast states enjoy the highest median earnings. However, a comparison of the 1956 and 1952 surveys indicates a narrowing of the regional gap in median earnings.

Copies of the 1956 *Professional Engineers Income and Salary Survey* may be obtained for $1 from NSPE headquarters, 2029 K Street, Northwest, Washington 6, D. C.

Meetings

AND EXPOSITIONS

Sept. 20—

Malleable Founders' Society. Fall Meeting to be held at Hotel Cleveland, Cleveland. Further information can be obtained from society headquarters, Union Commerce Bldg., Cleveland 14, Ohio.

Sept. 23-25—

American Society of Mechanical Engineers. Fall Meeting to be held at Hotel Statler, Hartford, Conn. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 23-25—

American Society of Mechanical Engineers. 12th Annual Conference of the Petroleum Div. to be held at Hotel Mayo, Tulsa, Okla. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 23-25—

Standards Engineers Society. Sixth Annual Meeting to be held at Hotel Commodore, New York. Further information can be obtained from G. H. Kitchen, Bell Telephone Laboratories Inc., Room 1B-118, Murray Hill, N.J.

Sept. 23-26—

Association of Iron and Steel Engineers. Annual Convention to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 24-25—

Sixth Annual Industrial Electronics Symposium to be held at the Morrison Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from H. L. Garbarino, Armour Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Sept. 30-Oct. 1—

Material Handling Institute Inc. Joint Industry Fall Meetings to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from institute headquarters, 1 Gateway Center, Pittsburgh 22, Pa.

Oct. 7-9—

American Society of Lubrication Engineers — American Society of Mechanical Engineers. Joint Lubrication Conference to be held at the Royal York Hotel, Toronto. Further information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

Oct. 7-9—

Second Conference on Manufacturing Automation to be held at Purdue University, West Lafayette, Ind. Sponsors are Purdue and *Automation* magazine. Further information can be obtained from the Editor, *Automation,* Penton Bldg., Cleveland 13, Ohio.

Oct. 7-9—

National Electronics Conference. Annual Meeting and Show to be held at the Sherman Hotel, Chicago. Further information can be obtained from American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

(*Please turn to Page* 36)

When your gears are designed, engineered and produced by SIER-BATH . . .

- **You get the ONE BEST GEAR DESIGN for each application,** giving your machines such improved performance and competitive advantages that increased sales follow naturally.
- **You have gears that run quietly and without vibration.**
- **You avoid early gear wear and failure.**

Join all the other Sier-Bath customers who let us handle their gear requirements from original design to ultimate superiority for their machines. Send your gear drawings—or request a Sier-Bath gear specialist to discuss your gear problems, without obligation.

Now available! Crown-Ground Spur and Helical Gears to 12" diameter, 4 pitch

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9237 Hudson Blvd. North Bergen, N. J.
Established 1905 Member A.G.M.A.

Also Manufacturers of Rotary Pumps and Flexible Gear Couplings

Sier-Bath PRECISION GEARS

All kinds of gears—all materials
Made—cut—shaved—ground tooth
42" maximum diameter
12 or more of a kind, depending on size.

Circle 422 on page 19

When It Comes to Your Reproduction Equipment...

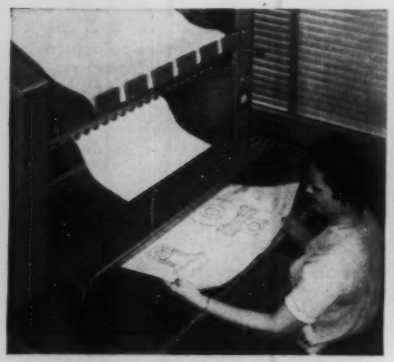
It May Be LATER Than You Think!

If more than a few years have gone by since you acquired your reproduction equipment, chances are it's costing you unnecessary time, man hours, and money. It may well turn out to be a bottleneck in your efforts to meet growing production boom demands.

Compare your equipment with the modern Bruning machines shown here. You should be getting the advantages offered by such advanced models as the new "575"... greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, front or rear print delivery. You should be benefiting by the problem-free installation and operation of Copyflex —no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

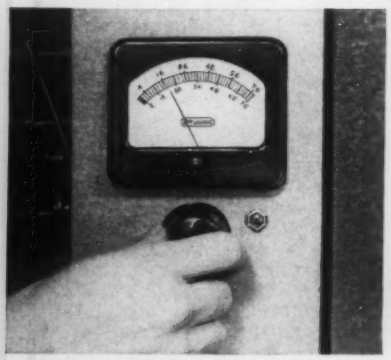
If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Act now by mailing the coupon. You'll be glad you did!

Copyflex Gives You All These Modern Reproduction Advantages!



Greater Convenience of Operation!

Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.



Faster Mechanical Speeds!

New Copyflex models introduced within the past two years offer sharply increased speeds—up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.

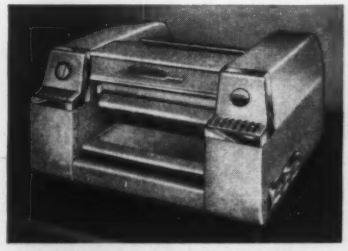
Problem-Free Installation and Operation!

Clean, quiet, odorless... Copyflex requires no vents or plumbing. Precision-engineered design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation.

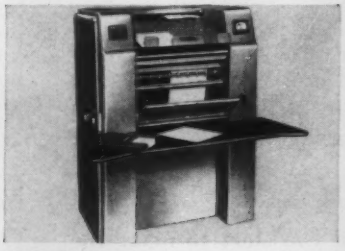
Just Out! *New, 75 f.p.m. Copyflex Model 575!*

Now when you need it! Here is the fastest, easiest-to-use Copyflex machine ever built!

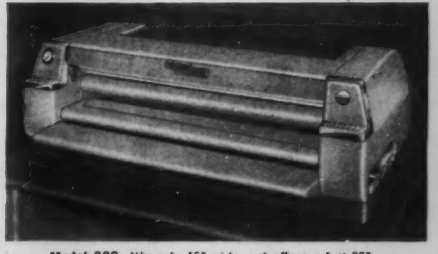
Here is the whiteprinter that has everything you could want in a reproduction machine—a super-fast mechanical speed of up to 75 feet per minute, a fast-printing exposure lamp which can be operated at either 7,500 or 5,000 watts with the flick of a switch, a full 46-inch printing width—*plus* many operator conveniences. The powerful, two-stage lamp provides the proper latitude for assuring the production of sharp, high contrast prints of all types of translucent originals, at the fastest possible rate. Operator conveniences include: one-knob speed control, with perfect, automatic synchronization of print exposure and development; improved, air-foil type automatic separation of exposed prints from originals; automatic stacking of tracings and prints; front or rear delivery; and a lamp shield control which facilitates the reproduction of extra-fast printing originals. The new Model 575 will pay for itself many times over in your drafting room by bringing you increased savings in time and man hours.



Model 110. When you need prints of such smaller size originals as specification sheets and check prints, this handy table-top machine turns them out in a jiffy without tying up your big machine. It has a printing width of 11". Makes 8½ x 11 prints for less than 1¢ each for materials. Operates on 115 volt A.C.



Model 250. It takes less than a square yard of floor space, yet offers a printing width of 18½" and a fast mechanical speed of 30 f.p.m. Automatic separation and stacking, one-knob control, and an extra-large feed board simplify and speed operator's work. Operates on 220 volt A.C.



Model 300. It's only 46" wide, yet offers a full 30" printing width! This remarkable low-priced table-top machine brings "inside" reproduction within the means of the smallest department or firm, makes an ideal "extra" machine for large companies. Operates on 115 volt A.C.

BRUNING *Copyflex*

Best Process! Best Machines!
Best Selection of Materials!

Offices in 38 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto, Ont.

Charles Bruning Company, Inc., Dept. 93-K
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following Copyflex machines: _____

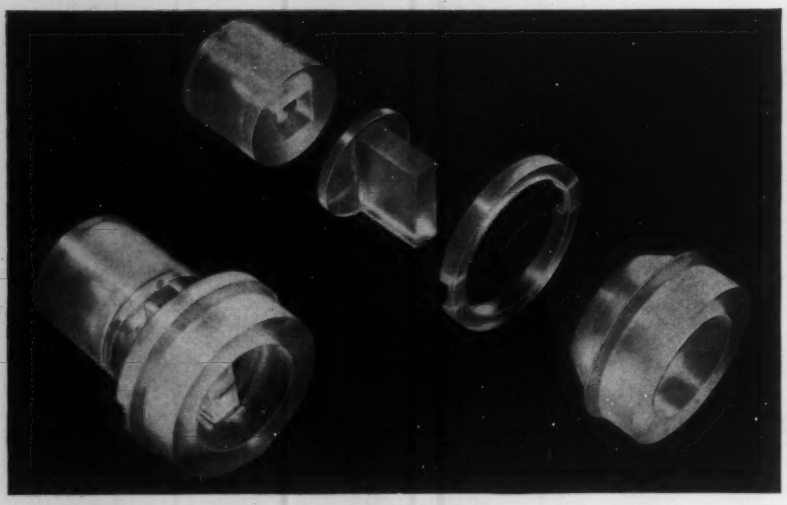
Name _____ **Title** _____

Company _____

Address _____

City _____ **County** _____ **State** _____

Circle 423 on page 19



prove it works **before** you go into production

Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1083 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with

PRECISION METALSMITHS, Inc.

Investment Castings

News Roundup

(*Continued from Page* 33)

Oct. 7-11—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 9-11—

Society for Experimental Stress Analysis. Annual Meeting to be held at Hotel El Cortez, San Diego, Calif. Further information can be obtained from SESA Secretary-Treasurer, Dr. W. M. Murray, P. O. Box 168, Cambridge 39, Mass.

Oct. 9-11—

Fourth Annual Symposium of High Vacuum Technology to be held at Hotel Somerset, Boston. Sponsor is the Committee on Vacuum Techniques, P. O. Box 1282, Boston 9, Mass.

Oct. 13-17—

Pressed Metal Institute. Annual Executive Meeting to be held in Castle Harbour, Bermuda. Additional information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 16-18—

American Institute of Electrical Engineers. Conference on Computers in Control to be held at the Chalfonte-Haddon Hall Hotel, Atlantic City, N. J. Additional information can be obtained from Prof. J. G. Truxal, Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn 1, N. Y.

Oct. 17-18—

National Conference on Industrial Hydraulics to be held at Hotel Sherman, Chicago. Sponsors are Armour Research Foundation and Illinois Institute of Technology. Further information is available

from Conference Secretary, Armour Research Foundation, 10 W. 35th St., Chicago, Ill.

Oct. 17-19—

National Society of Professional Engineers. Fall Meeting to be held at Grand Pacific Hotel, Bismarck, N. Dak. Further information can be obtained from society headquarters, 2029 K St., N. W., Washington 6, D. C.

Oct. 23-25—

National Fluid Power Association. Fall Meeting to be held at Hotel Statler, Washington, D. C. Additional information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

Oct. 24-25—

Aircraft Electrical Society. 14th Annual Display of Aircraft Electrical Equipment to be held in the Pan Pacific Auditorium, Los Angeles. Additional information is available from Edward Ryerson, Display Director, 380 Entrada Dr., Santa Monica, Calif.

Oct. 28-31—

American Nuclear Society. Second Winter Meeting to be held concurrently with the Fourth Annual Meeting of the Atomic Industrial Forum and the Third Trade Fair of the Atomic Industry at the Coliseum, New York. Additional information can be obtained from Mr. John Burt, J. M. Mathes Inc., 260 Madison Ave., New York 16, N. Y.

Nov. 2-8—

National Metal Exposition and Congress to be held at the International Amphitheater, Chicago. The American Society for Metals; the Institute of Metals Div. of the American Institute of Mining, Metallurgical and Petroleum Engineers; and the Society for Non-Destructive Testing will hold technical sessions.

Second World Metallurgical Congress will be held in conjunction with the Metal Show. Information on both meetings can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

... the two-way answer to fastening problems

Here's a combination that slashes production costs and gets rid of fastening problems in a hurry—Milford Rivets made to high-quality standards to assure a better finished product for you . . . Milford automatic rivet-setting machines that can be quickly adapted to your particular fastening needs.

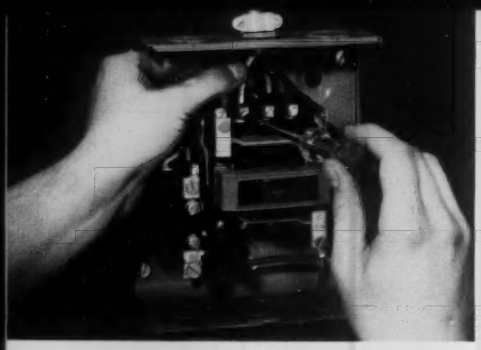
To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

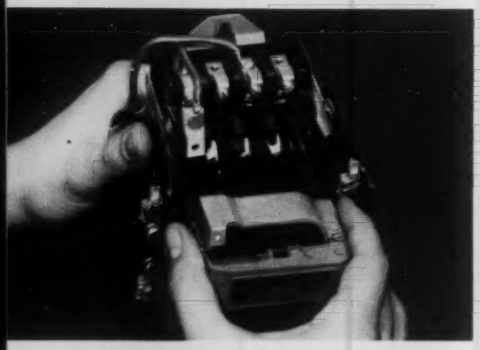
MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

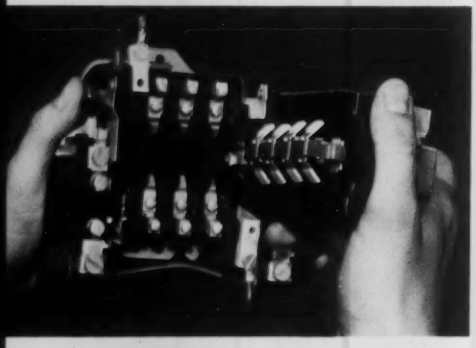
Circle 425 on page 19 Circle 426 on page 19→



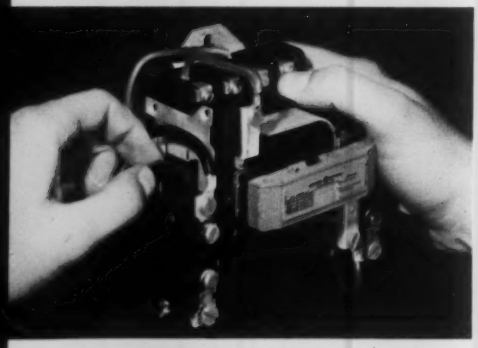
NEW **GREATER WIRING SPACE**
Wrap-around cover—removable enclosure sides make wiring much easier.



NEW **SNAP-SLIDE CONSTRUCTION**
Principal components quickly disassembled for easier inspection and maintenance



NEW **"VERTICAL" CONTACTS**
Continuous dependable operation of new starter—even in dusty atmospheres



NEW **ADJUSTABLE OVERLOADS**
Overload trip setting can be adjusted plus or minus 15% of nominal heater rating.

General Electric announces

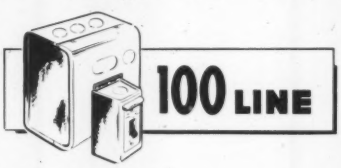
NEW Size 0 and 1 Magnetic Starters—42% Smaller in Size

General Electric now offers a new line of Size 0 and 1 magnetic starters that is 42% smaller than previous open forms and is built to the new NEMA ratings. The new starters with "snap-slide" construction provide easier inspection and maintenance because principal components snap or slide together. Completely new and radically different in design, this line of starters offers:

- wrap-around cover with spring latch—easily removed without tools for inspection
- removable sides for greater accessibility
- straight-through wiring speeds installation
- pressure-type terminals make wiring easy
- vertically-slanted contacts give higher tip pressure, reduce possibility of contact welding
- long life "kick-off" spring provides clean break of contacts in any mounting position
- strongbox coil with Mylar* insulated start wire for longer coil life
- overload relays adjustable for ±15% of trip setting
- nine field modification kits for greater flexibility
- new maximum NEMA ratings up to 7½ hp at 220 volts and 10 hp at 440 volts

Two additional features of the new magnetic starter are extremely quiet operation and lower inrush requirements of the coil. Sound absorbing material around the magnet lowers the operating noise level. Lower coil inrush current will allow you to use a 47% lower rated control transformer with this starter—saving you money and mounting space.

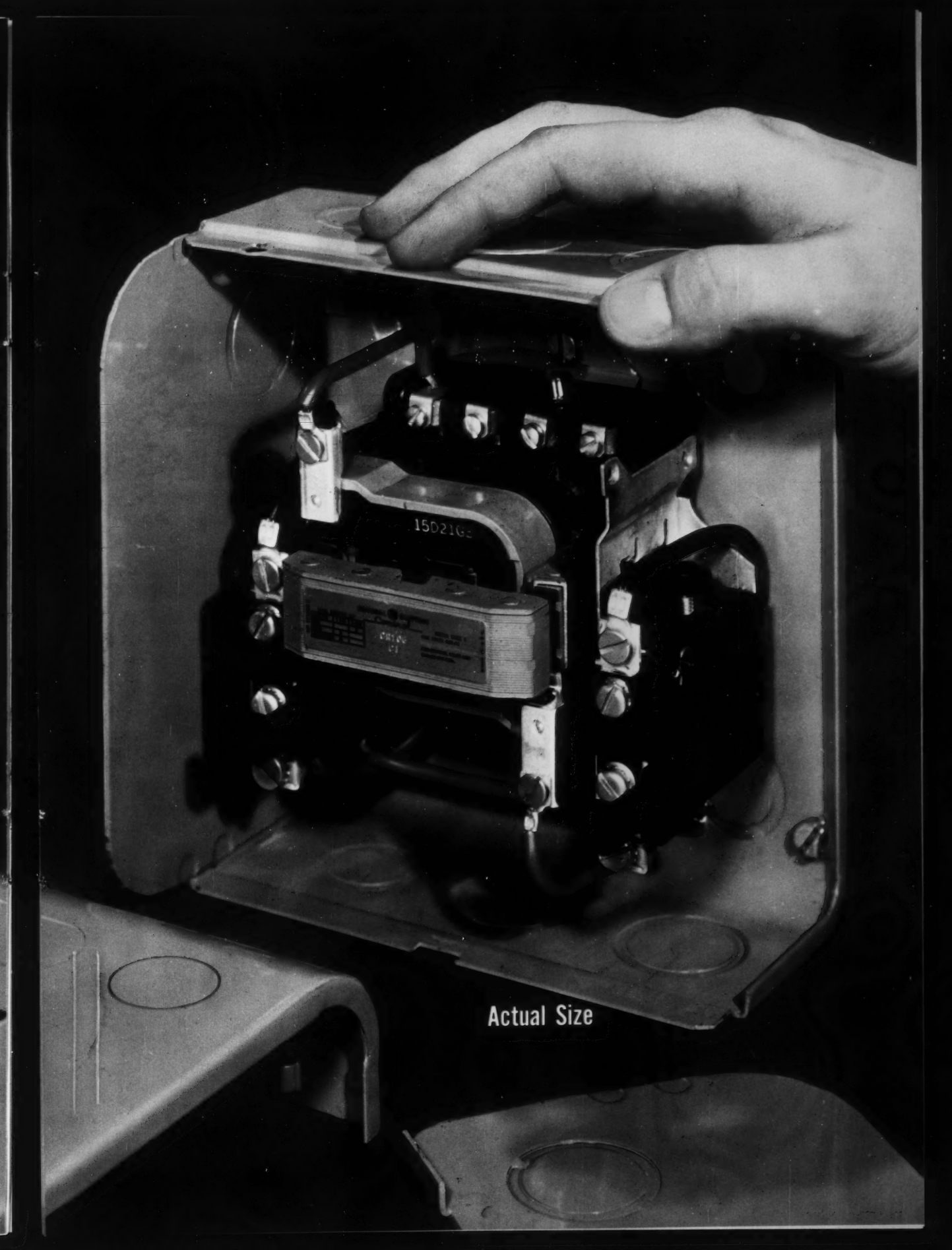
Size 0 and 1 General Electric starters are available now in non-reversing, combination, reversing and multispeed forms. Contact your nearest General Electric Sales Office or Distributor, or write Advertising Section 731-13 for the 20-page bulletin describing the line. Ask for GEA-6611. General Electric Company, Bloomington, Illinois.



*Trade-mark of DuPont Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC

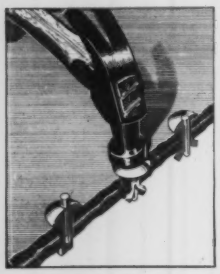

Actual Size

MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

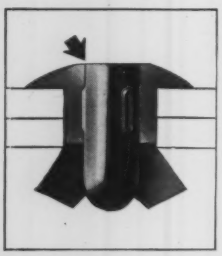
Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS



Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

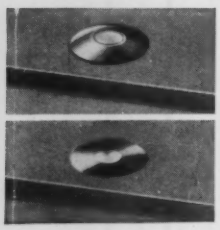
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

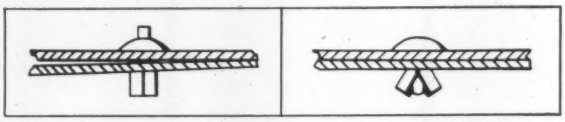
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



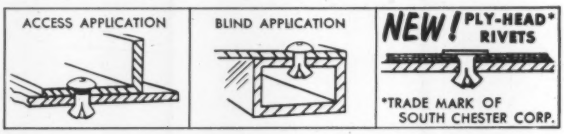
Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up.

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION



Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

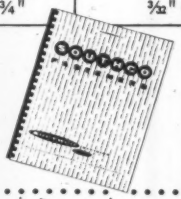
DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 3/8"
3/16"	1/8" to 3/4"	1/32" to 5/8"
1/4"	7/32" to 3/4"	1/16" to 5/8"

STEEL

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 5/8"
1/4"	1/4" to 3/4"	3/32" to 5/8"

FREE FASTENER HANDBOOK . . . Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other specialty fasteners. 52 pages, in two colors.

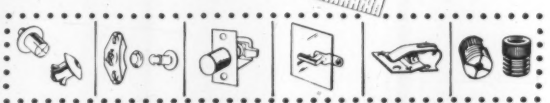
Write on your letterhead to Southco Division, South Chester Corporation 237 Industrial Highway, Lester, Pa.



SOUTHCO FASTENERS

LION

©1957



Circle 427 on page 19

ST. REGIS PAPER CO.'s three-year tests proved Norgren MICRO-FOG best for lubricating the bearings on these paper machine dryer sections.

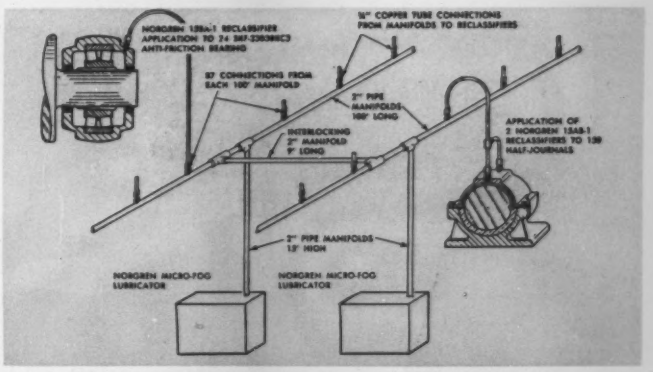
174 BEARINGS ON PAPER MACHINE DRYER SECTIONS LUBRICATED BY NORGREN MICRO-FOG

...Result of 3 Years of testing by St. Regis Paper Co.

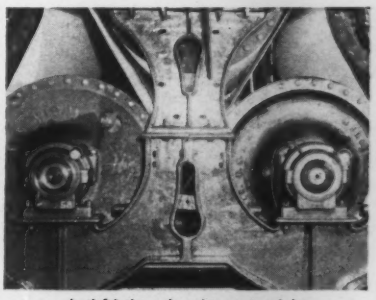
The block grease lubrication system for the 174 bearings on the dryer sections of this machine was inadequate, requiring supplementary hand lubrication, and was costly to maintain. Three years of extensive tests by St. Regis, comparing Norgren MICRO-FOG with other methods of lubrication, proved to them that MICRO-FOG is best. By changing to MICRO-FOG Lubrication, St. Regis gained the following advantages:

1. MICRO-FOG Lubrication is by far the most thorough.
2. Maintenance of lubrication system is easier.
3. Bearing temperatures have been reduced.
4. Less lubricant is consumed.
5. Paper losses due to excessive lubrication have been ended.
6. Lint and other contaminants can't enter bearings.
7. MICRO-FOG is easy to operate.

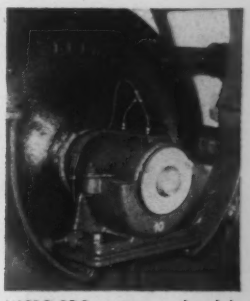
For complete information about this application, call your nearby Norgren Representative listed in your telephone directory—or **WRITE FOR BLUEPRINT MF-23.**


NORGREN 12SA-1 RECLASSIFIER APPLICATION TO 24 387-2383BRC3 ANTI-FRICTION BEARING
½" COPPER TUBE CONNECTIONS FROM MANIFOLDS TO RECLASSIFIERS
87 CONNECTIONS FROM EACH 100" MANIFOLD
2" PIPE MANIFOLDS 100" LONG
INTERLOCKING 2" MANIFOLD 9" LONG
APPLICATION OF 2 NORGREN 12SA-1 RECLASSIFIERS TO 130 HALF-JOURNALS
2" PIPE MANIFOLDS 13' HIGH
NORGREN MICRO-FOG LUBRICATOR
NORGREN MICRO-FOG LUBRICATOR

Schematic drawing, showing how Norgren MICRO-FOG Lubrication is conveyed to the bearings.



Anti-friction bearing at right shows how one MICRO-FOG distribution line serves each bearing. Note oil leakage at bearing at left where old lubrication system was used during test.

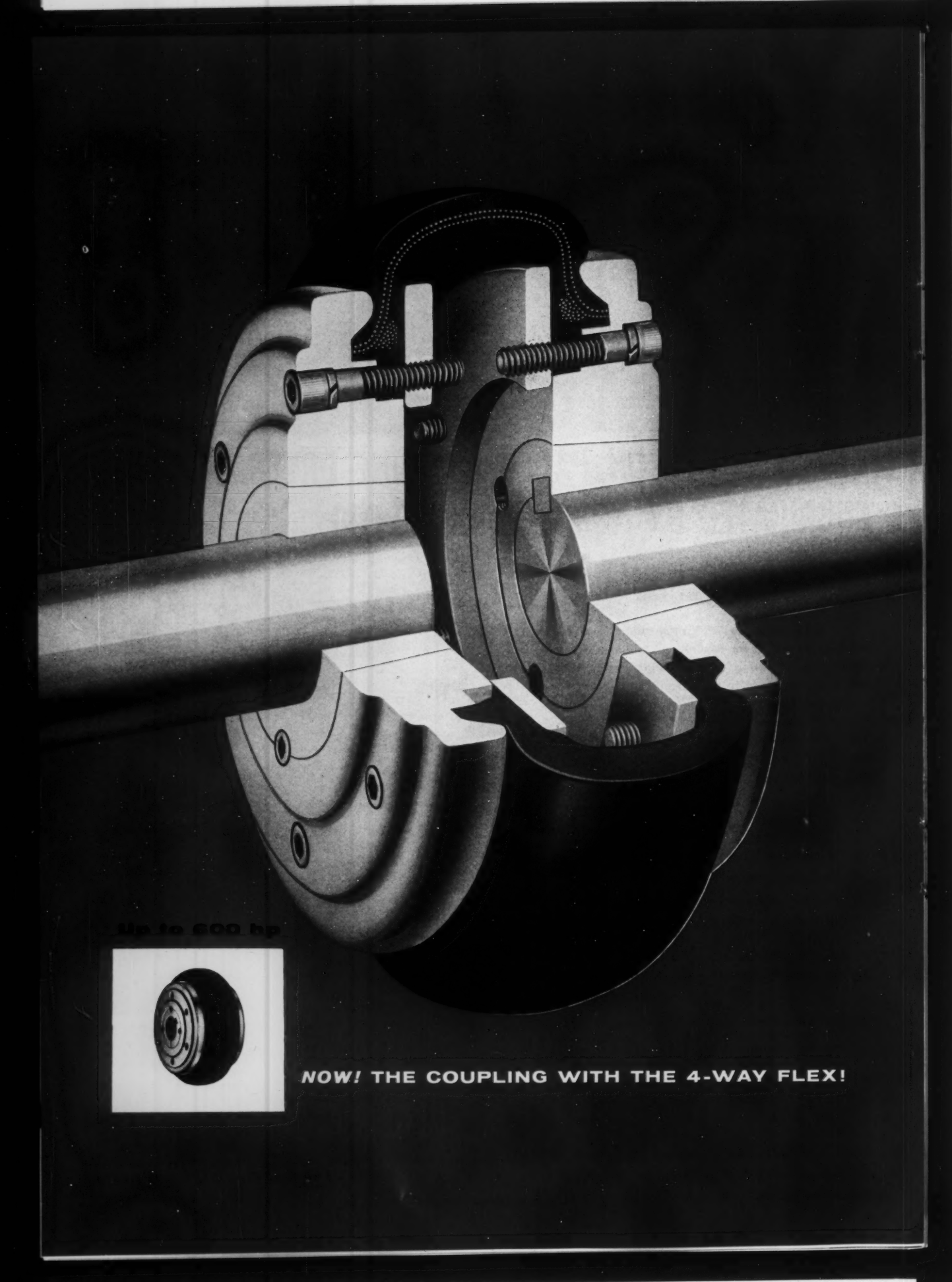


MICRO-FOG enters each plain bearing through two lubrication lines, providing a continuous protective coating of fresh lubricant over the entire surface of the bearing.

MICRO-FOG by NORGREN

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • • • ENGLEWOOD, COLORADO



NOW! THE COUPLING WITH THE 4-WAY FLEX!

Para•flex

FLEXIBLE CUSHION COUPLING

THE NEW IDEA IN FLEXIBLE COUPLINGS... WITH A FLEXING BODY THAT AUTOMATICALLY COMPENSATES FOR ALL COMBINATIONS OF MISALIGNMENT AND END FLOAT... AND CUSHIONS SHOCK LOADS!

THIS Coupling "swallows up" misalignment! Its ability to handle multiple displacement is exceeded only in a universal joint. It outperforms the most complex coupling mechanisms—yet it operates with the simplicity—*and the dependability*—of a modern tire!

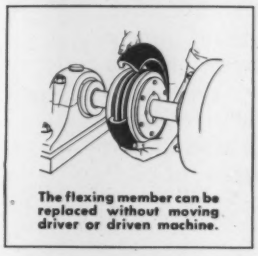
The technological advances that contribute to the miracle of today's truck tires, which are engineered to carry tremendous loads at high speeds and stand terrific shock, have made this new type of coupling possible.

The heart of Para-flex is a tire with synthetic tension members bonded together in rubber. It is pliant. It "fits itself" to changing shaft conditions—angular, parallel, end-float, *or any combination of all three!* Depending upon the size of coupling and duration of shaft misplacement, it handles angular misalignment up to 4°, parallel up to ⅛" and end-float up to 5/16".

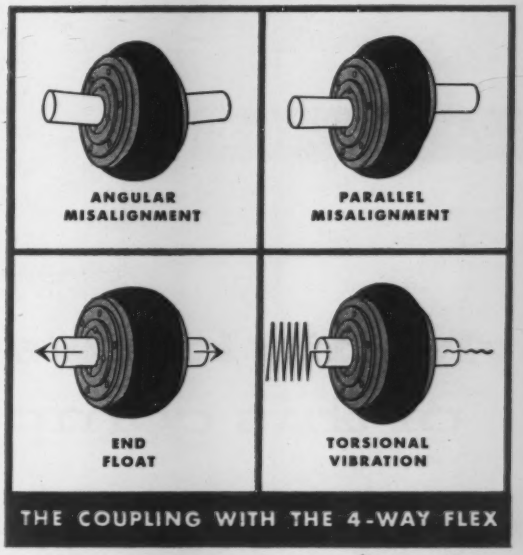
It cushions the stresses of shock loads to a remarkable degree. And it tends to absorb torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

There is no metal-to-metal contact between shafts. They are insulated. No lubrication is required.

Para-flex takes a minimum of space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine!*



The flexing member can be replaced without moving driver or driven machine.



THE COUPLING WITH THE 4-WAY FLEX

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 600 hp at 900 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

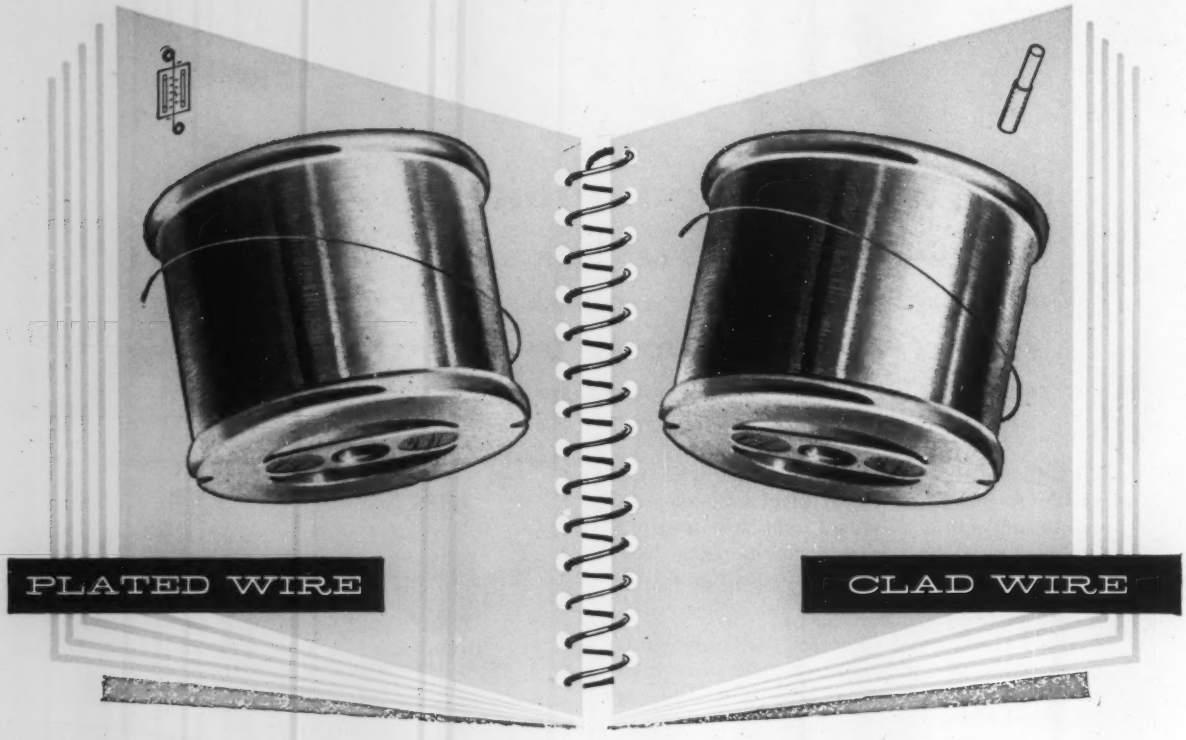
DODGE MANUFACTURING CORPORATION, 3300 Union Street, Mishawaka, Indiana

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your classified telephone directory—or write us.

Circle 429 on page 19



Sylvania knows both sides of this composite wire story

WHICH KIND OF WIRE will do your job better . . . plated? or clad? In Sylvania's case histories, one usually comes out on top, pricewise, performancewise . . . or both.

And perhaps Sylvania can help you decide which it is for you. As a manufacturer of both types, we'll give you our best and objective opinion of whether you could better be using a plated wire where you're now using clad . . . or clad where you're now using plated.

No matter what wire properties your application calls for, it will help you to know that Sylvania is one of the nation's top custom platers of wire. Plating ranges from flash to 20% by weight in a wide range of materials in sizes from .250″ to .002″. Or, your custom wire can be clad in just about any combination of cold-drawn materials.

Alloy wires too, are available on both a custom and standard basis, as well as custom wire welds, and plated metal strip. Sylvania Parts Division is your source for metal stamping, plastic molding and special components as well. Write for complete information.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

4-way service from one source

Circle 430 on page 19

NOW–

servo valves designed specifically for industrial use

New Honeywell hydraulic valve and transistor amplifier team offers unprecedented flexibility

NOW YOU can choose from a line of Honeywell servo valves specifically designed for industrial use.

Honeywell servo valves and transistor amplifier combinations make new building blocks available for dozens of applications requiring control of hydraulic variable delivery pumps, hydraulic motors and cylinders.

They provide the advantages of electronics *and* hydraulics in machine control systems. Rugged and dependable, they are smaller and more compact, have high speed of response, are easy to adjust and inexpensive to install.

They make it possible to apply electro-hydraulic control to many applications previously limited to all-electric drives. They also permit superior electronic control of existing hydraulic equipment.

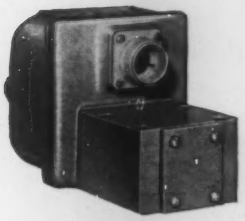
For complete information, including realistic delivery dates, call, wire or write Minneapolis-Honeywell Machine Controls Division, **MD-9-187,** Fourth Ave., South, Minneapolis 8, Minnesota.

Honeywell

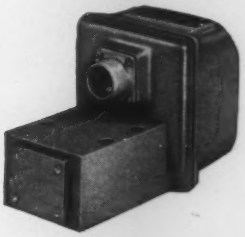
First in Controls

Hydraulic Servo Valves—Three and four-way valves designed for pressure-flow-control use in electro-hydraulic servo systems. Can be ordered with integral feedback transducer (output signal proportional to valve displacement) to provide an additional feedback loop in the servo system. Weight: 4.5 lbs. Input power: 4 watts. Operating Pressure: 100 to 1000 psi. Proof Pressure: 3000 psi. Operating Temperature: 0° to 160° F. Natural Frequency: 280 c/s.

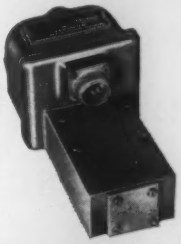
Flow Specifications for Typical Individual Valve Models



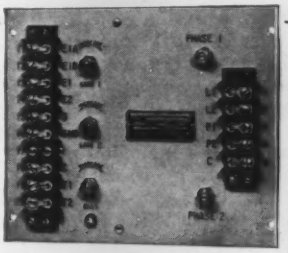
3-Way Valve (XVJ300)
Output Flow (no load)
100 psi—3.5 gpm
1000 psi—9.9 gpm



3-Way Valve (XVJ302)
Output Flow (no load)
100 psi—2.0 gpm
1000 psi—6.0 gpm



4-Way Valve (XVJ303)
Output Flow (no load)
100 psi—1.5 gpm
1000 psi—5.0 gpm



Amplifier (XRJ301)

Transistor Servo Amplifier. High gain, multiple input amplifier with superior reliability . . . Drives electro-hydraulic servo valves, d-c relays and small d-c servo motors up to 5 watts . . . Weight: 5 lbs. . . . Voltage and Frequency: 115 volts, 60 cps. . . . Power consumption: 20 watts . . . Input Impedance: 10,000 ohms . . . Load Impedance: 50 to 1000 ohms . . . Sensitivity: 1 mv input signal produces differential current of 15 ma in a load of 70 ohms, with maximum gain . . . Maximum Ambient Temperature: 135° F.

Circle 431 on page 19

how Vacuum Metals FERROVAC solved critical surface problem for Bausch & Lomb . . .

The jewelers' rolls Bausch & Lomb use to roll gold-alloy wire for eyeglass frames must be *mirror-smooth*. Rolls of conventional air-melted alloys just didn't work out economically. A normal amount of nonmetallic inclusions in the metal meant they had to be ground and reground, polished and repolished, before the surface was satisfactory. And even then, many rolls had to be scrapped when finishing uncovered inclusion pits.

The solution to this problem proved to be Vacuum Metals FERROVAC® Airdi 150. A better finish was obtained without any regrinding—and the number of scrapped rolls fell to zero. Here's why: Vacuum-melting removes the gases which create nonmetallic inclusions in the molten metal before they get into the product. This means cleaner metal, smoother surfaces. What's more, vacuum-melting improves fatigue, creep and impact strengths . . . reduces brittleness.

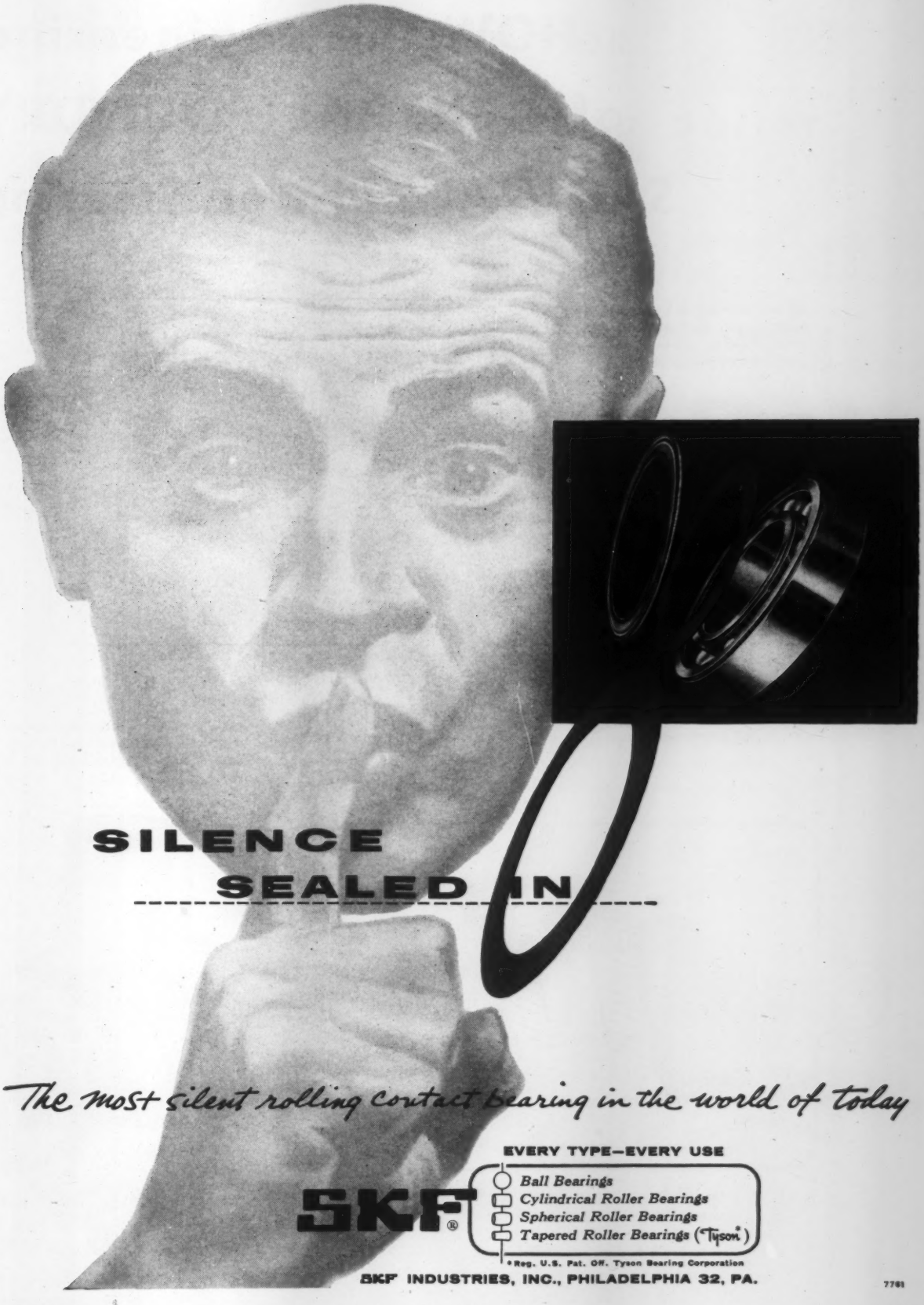
Vacuum-melted metals are the answer to jobs where surface is critical—like gauge blocks, plug and ring gauges, rolls for aluminum foil—as well as many other specially demanding applications. They're available in most grades and sizes, including special ferrous and non-ferrous alloys. Write now for a free analysis sheet on which to describe your application. It will help us both decide how vacuum-melted metals can serve you best. ***Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, New York.***

VMC®

VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

Circle 432 on page 19



The most silent rolling contact bearing in the world of today

EVERY TYPE—EVERY USE

SKF®

Ball Bearings
Cylindrical Roller Bearings
Spherical Roller Bearings
Tapered Roller Bearings (Tyson®)

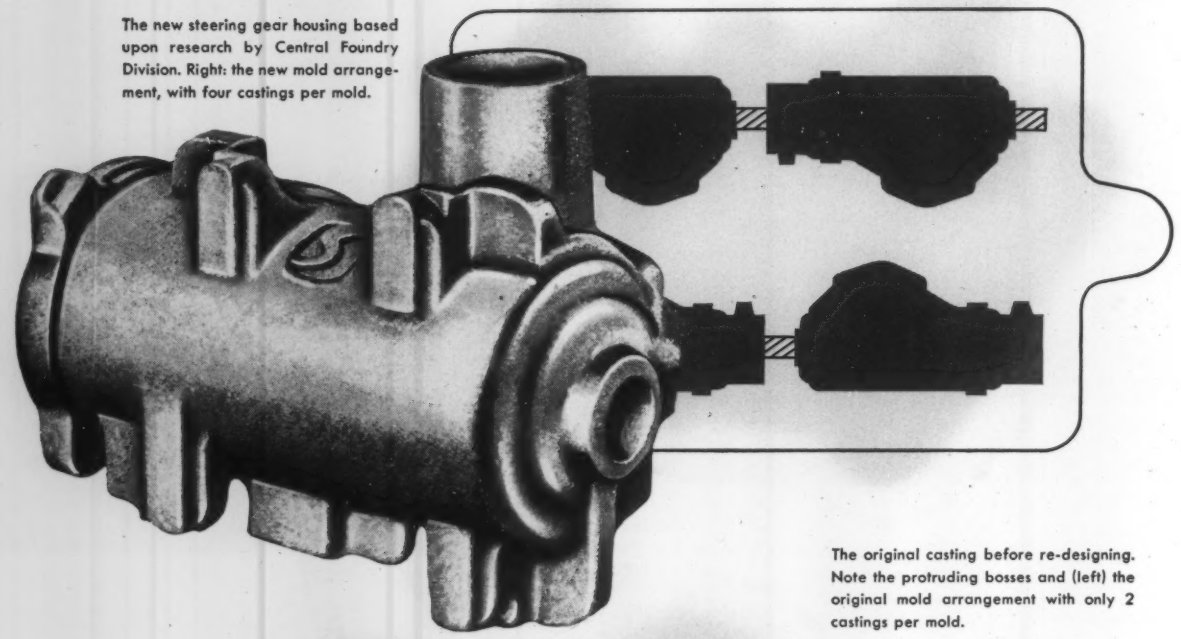
®Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

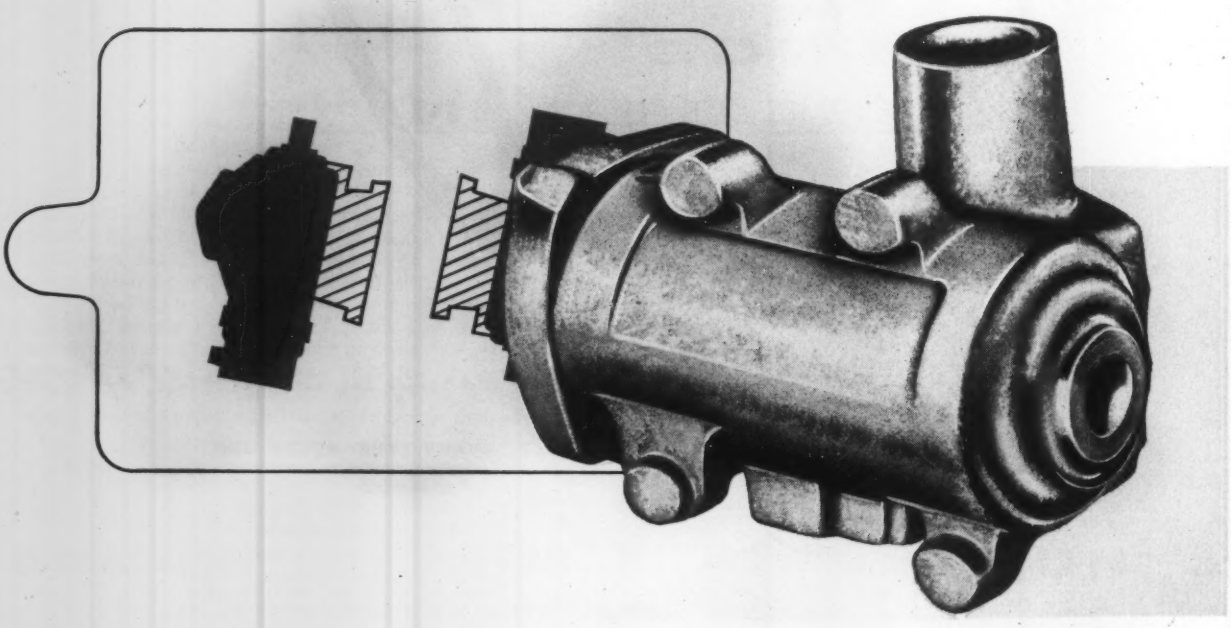
7761

HOW the engineering of CENTRAL FOUNDRY *SAGINAW Power Steering*

The new steering gear housing based upon research by Central Foundry Division. Right: the new mold arrangement, with four castings per mold.



The original casting before re-designing. Note the protruding bosses and (left) the original mold arrangement with only 2 castings per mold.



and research facilities DIVISION developed a better *Housing at lower cost*

Here is an example of how Central Foundry research and engineering are helping reduce manufacturers' costs and at the same time providing improved castings. In this case, the malleable iron casting is the housing for the famous Saginaw Power steering assembly.

At the lower left is shown the original housing. This casting required 5 cores . . . 3 of them external. As the mold plan shows, only 2 castings per mold were possible.

Working together, Central Foundry and Saginaw Steering Gear engineers first attacked the problem of eliminating some of the costly cores. Thorough experimentation resulted in the elimination of the protruding bosses on the casting; a step which reduced the required number of cores to 2, and increased the number of castings per mold to 4. This is illustrated above (left).

By such techniques as radiography and stress analysis, experimental castings were carefully analyzed. Stress analysis indicated how and where section and wall thickness might be reduced. Radiography disclosed the degree of soundness of the test castings.

Based upon this new design came a production casting of improved quality and lower in weight by two pounds per casting. Correlated benefits were a reduction in machining area and greater yield-per-pound of iron.

If you have a casting problem it will pay you to bring it to Central Foundry Division. Our modern research staff is ready to employ radiography, stress analysis, sonic testing, spectroanalysis, and our engineering knowledge and experience to help you improve your product and lower your costs.

Central Foundry Division produces high-quality grey iron, malleable iron, and ArmaSteel castings . . . in quantity, by either the sand or shell-mold process. The two books, "ARMA-STEEL" and "SHELL CASTING AT CENTRAL FOUNDRY" completely explain the materials, services, and techniques which are available to you through Central Foundry Division. Write today for your free copies of these valuable, fact-filled books.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

79

Circle 434 on page 19

if it can be pushed through a pipe . . .

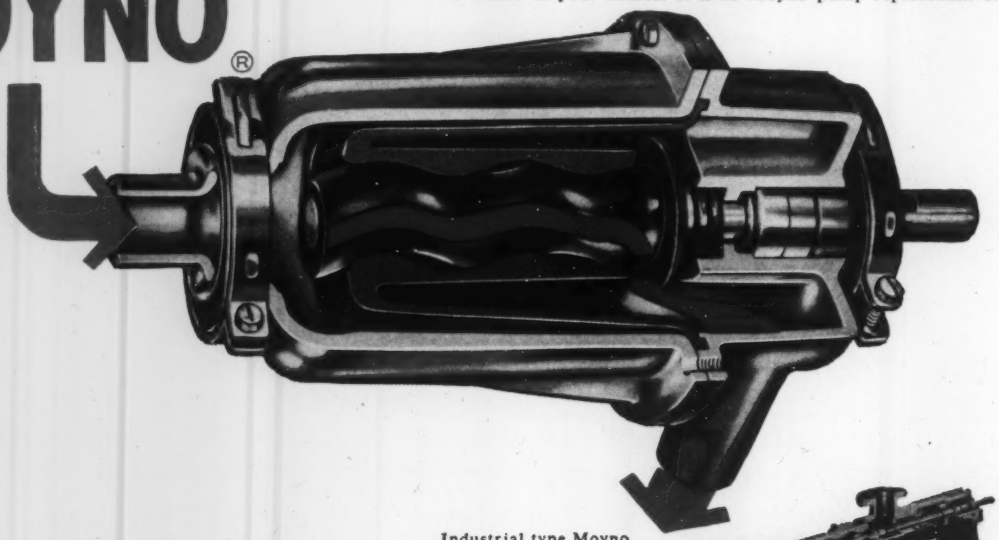
you can pump it with a

MOYNO®

No doubt, in your plant, certain materials are being moved by hand expensively that could be pumped economically by a Moyno. They pump anything that can be forced through a pipe . . . from very thin liquids to heavy, non-pourable abrasive substances . . . even materials containing suspended particles! As the illustration shows, progressing cavities, formed by the helical screw-like rotor turning inside the double-helical stator, move smoothly along, carrying the material with them . . . the cavities don't squeeze the substance . . . can't stick or gum up. Moyno pumps will not cause churning, foaming . . . won't aerate or vapor-lock!

Moynos are adaptable for a wide range of substances simply by modifying the materials the pumping elements are made of. They are available to pull up to 29" of vacuum while discharging under pressure. If you have a pumping problem, chances are a Moyno will solve it!

Write today, for Bulletin 50 MD or look in the yellow pages for name of your nearest R & M Moyno pump representative.



Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Motors | Fans | Hoists | Moyno® Pumps | Propellair® (Industrial) Fans

Circle 435 on page 19

You can expect extremely long life from Skinner Solenoid Valves. Here's why...

In the lab shown above, dozens of Skinner valves are life-cycled 24 hours a day, 7 days a week, at speeds as high as 600 cycles per minute. It is here that we try out new designs, new materials, new construction methods. It is here that we test the stability of our welded joints . . . the resistance to burnout of our coils . . . the effectiveness of our positive spring returns . . . the better seal we obtain by eliminating packings. And it is here we find positive proof of Skinner valves getting over 20,000,000 cycles without leakage.

Service records of many millions of trouble-free cycles indicate that these constant laboratory tests are worthwhile and necessary to assure outstanding performance on critical applications.

For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 429.

Skinner Solenoid Valves are distributed nationally

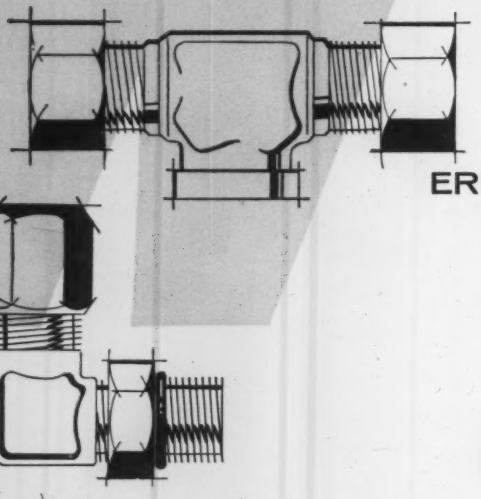
Circle 436 on page 19

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN
CONNECTICUT
(185 EDGEWOOD AVENUE)

THE CREST OF QUALITY

WEATHERHEAD

steel tube fittings for high-pressure applications

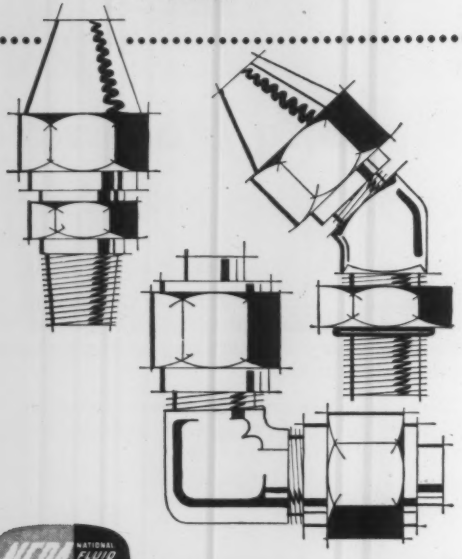


ERMETO®

NO FLARING • NO THREADING
NO WELDING • NO SOLDERING

Steel and stainless steel Ermeto fittings in sizes and types to meet any high-pressure need. Also straight-thread Ermeto fittings to meet new S.A.E. boss specifications.

NOTE—All 7000 Series straight-thread Ermeto fittings and components have corrosion-resistant "Weathercote" finish.



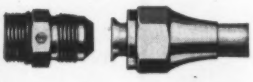
FLARE-TWIN*

S.A.E. 37° Flare-Twin (J.I.C.) fittings are available with Dryseal-thread or with new straight-thread in popular styles and sizes for S.A.E. "O" ring boss design. Available with cadmium-plate or new corrosion-resistant Weathercote finish.

Trade name for the new Weatherhead 37° flared fitting.

3-PIECE TYPE

2-PIECE TYPE



NFPA NATIONAL FLUID POWER ASSOCIATION

WEATHERHEAD
FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION
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DASH CONTROLS

BRASS

DRAIN AND SHUTOFF COCKS

SAE FLARE-TWIN (JIC)

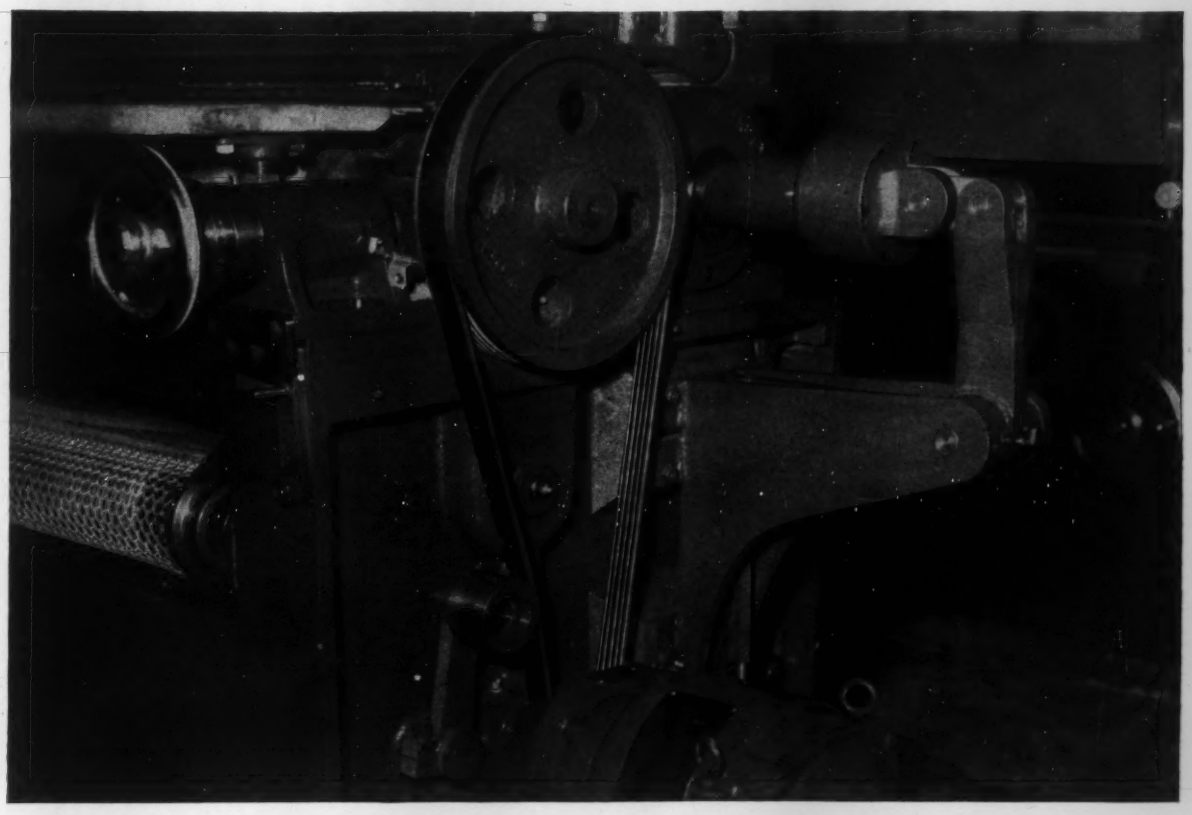
ERMETO®

SELFALIGN®

BULK HOSE AND REUSABLE HOSE ENDS

HOSE ASSEMBLIES

Circle 437 on page 19



HERE'S THE IDEAL DRIVE FOR SPACE SAVING DESIGN

. . . R/M *Poly-V®* Drive!

Space-saving advantages of this completely new concept in heavy duty power transmission can mean improved drive design for a wide variety of applications.

On this buffer drive, for example, installation of patented Poly-V Drive reduced sheave width 50%! Bonus advantages? *Faster* machine operating speeds, 20% lower drive costs . . . and elimination of costly "chatter" marks on textiles, leather and other materials caused by V-belt slap during buffing operations.

R/M Poly-V Drive employs a *single, endless* parallel V-ribbed belt running on sheaves designed to *mate precisely* with the belt ribs. Flat belt strength and simplicity *plus* the positive V-groove grip of V-belts gives Poly-V Drive *twice* the tractive surface of multiple V-belts of equal width . . . up to 50% more *power delivery* in the same space as a V-belt drive, or *equal* power in as little as ⅔ the space! There's less shaft overhang, too . . . less drive weight to meet heavy duty requirements.

Poly-V's single unit design also eliminates belt matching problems, greatly increases the life expectancy of both belts *and* sheaves, maintains more constant speed ratios under *all loads*. Just *two* cross sections of Poly-V Belt meet *every* heavy duty power transmission requirement—R/M Poly-V Drive cuts costly belt and sheave inventories to a new low!

Let the R/M engineers who developed this amazing drive help you determine the installation that will mean "More Use per Dollar" for the equipment you design or the equipment you use. Contact the R/M representative nearest to you . . . or write for Poly-V* Drive Bulletin #6638.

**Poly-V is a registered Raybestos-Manhattan trademark.*

RM735

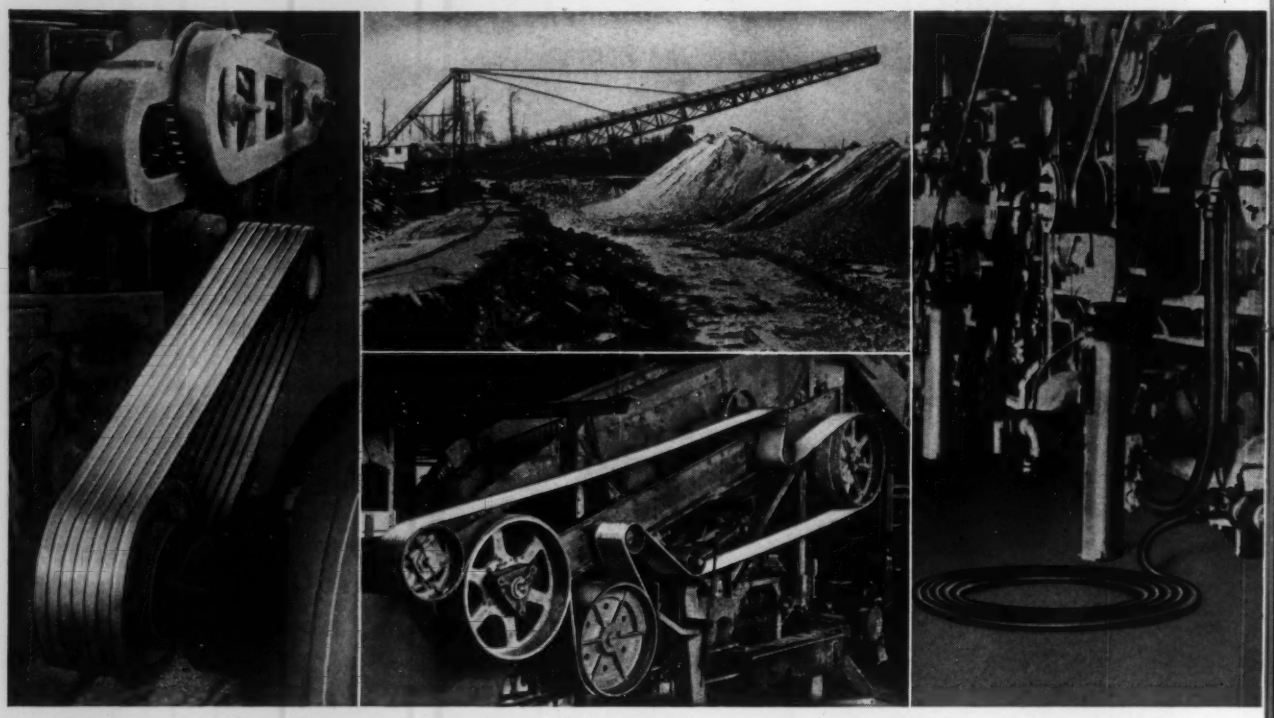
BELTS • HOSE • ROLL COVERINGS • TANK LININGS • INDUSTRIAL RUBBER SPECIALTIES

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products: Abrasive and Diamond Wheels • Brake Blocks and Linings • Clutch Facings • Asbestos Textiles • Mechanical Packings • Engineered Plastics • Sintered Metal Products • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

CALL ON R/M ENGINEERING SERVICE



R/M RUBBER PRODUCTS IMPROVE EQUIPMENT PERFORMANCE, REDUCE COSTS

Are conveyor belts, hose, V-belts or flat transmission belts important to the equipment you design? R/M custom engineers these and other mechanical rubber products to meet specific performance requirements. Ray-Man Conveyor Belt, for example, provides extra flexibility *and* tear resistance for heavy duty applications where thick, narrow belts and small pulleys are required.

Other R/M conveyor belts include special constructions for portable and package conveyors, grain and feed handling, and long-lift, high-tension installations. There's an R/M hose construction for every application, too. Light, flexible, Homoflex for air tools and water; all-purpose Allflex, ideal for use with air, water, oil, gases or mild chemicals. Where R/M feature hose constructions don't meet your special requirements, R/M specialists will engineer the hose that will!

Designers and users call R/M V-Belts "the smoothest running V-belts made." That's because Condor and R/M Super-Power V-Belts are made with flat sidewalls to assure better tensioning and grip, less slip—longer life on the most rugged drives. R/M's patented, new Poly-V® Drive combines the V grip of V-belts and the strength and simplicity of flat belts in a *single* endless belt drive that can deliver up to 50% *more* power in the same space as multiple-belt drives—or equal power in ⅔ the space! This revolutionary new drive concept completely eliminates belt matching problems. If your design calls for flat transmission belting, R/M offers a driving surface to meet every requirement from low tension to desired slip.

R/M engineering skill and advanced production facilities also enable them to mass produce precision molded parts in natural and synthetic rubber or silicone . . . custom-designed to meet your needs, delivered in time to meet production schedules. Let R/M specialists work with you.

**Poly-V is a registered Raybestos-Manhattan trademark.*

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 439 on page 19

FOR HELP IN SOLVING YOUR PROBLEMS

R/M VEE-FLEX...

for top performance under pressure

R/M Vee-Flex, the original convex-design hydraulic packing, is the best yet developed for tough applications. It is designed for every piston and rod, and is automatically self-sealing and self-adjusting, even at pressures of 6000 psi and above. Other features include precision molding and trimming: deep, thorough penetration of the compound into the fabric; rock-hard adapters to resist high pressures and to prevent extrusion.

If you have a packing problem, call on R/M's specialized packing engineering service. R/M makes a complete line of mechanical packings, and can also meet your requirements for "Teflon"* products and asbestos textiles.

A Du Pont trademark

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PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
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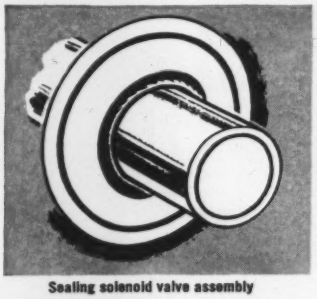
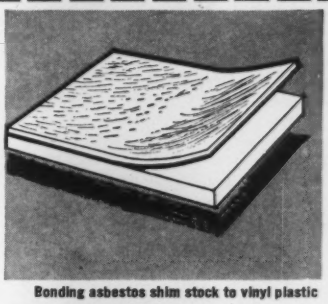
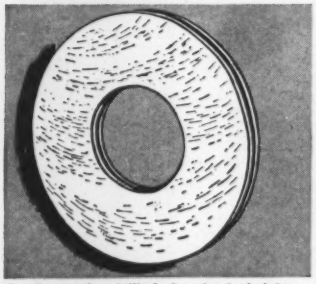


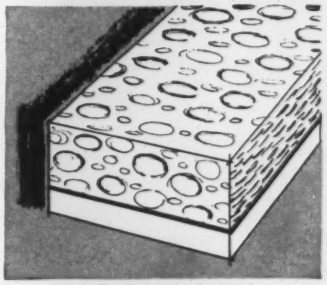
Sealing solenoid valve assembly



Bonding asbestos shim stock to vinyl plastic



Bonding semi-metallic facings to steel plates



Bonding sponge to steel

R/M Ray-BOND® ADHESIVES

simplify product design, cut costs

R/M adhesives, protective coatings, and sealers extend the horizons in the design of new products of all kinds. As in the products shown here—and in countless other applications—they bond parts together, help build stronger, more durable assemblies and, in addition, help reduce production costs.

R/M Ray-BOND adhesives, compounded of synthetic or natural rubber, resin bases of many types, and combinations of rubber and resins, have excellent bonding qualities and great resistance to heat. They are suitable for bonding diverse materials such as wood, glass, cork, plastics (including "Teflon"*), friction materials, metals and countless others. They resist temperature extremes ranging from −80°F to 700°F.

A Du Pont trademark

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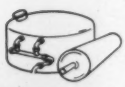
ADHESIVES DEPARTMENT
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

Circle 440 on page 19

No matter how you say it . . .

*TRANSLATION: CUTTING OIL

The performance and the brand are the same around the world

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oil—for closed hydraulic systems

Shell Alvania Grease—multi-purpose industrial lubricant

Shell Turbo Oil—for utility, industrial & marine turbines

Shell Rimula Oil—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils, a quality line of soluble cutting oils, permit higher speeds and greater feeds while extending tool life. They have excellent wetting and cooling properties and are not sticky or greasy.

Dromus® Oils have the added advantage of being easy to mix in hot or cold, hard or soft water. They form emulsions which remain stable in practically any concentration required in the shop.

Today Dromus Oils are available to your customers abroad. You can be sure that they will enjoy the same efficient performance your domestic customers rely upon.

• • •

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, N. Y., or 100 Bush Street, San Francisco 6, California.

SHELL DROMUS OILS

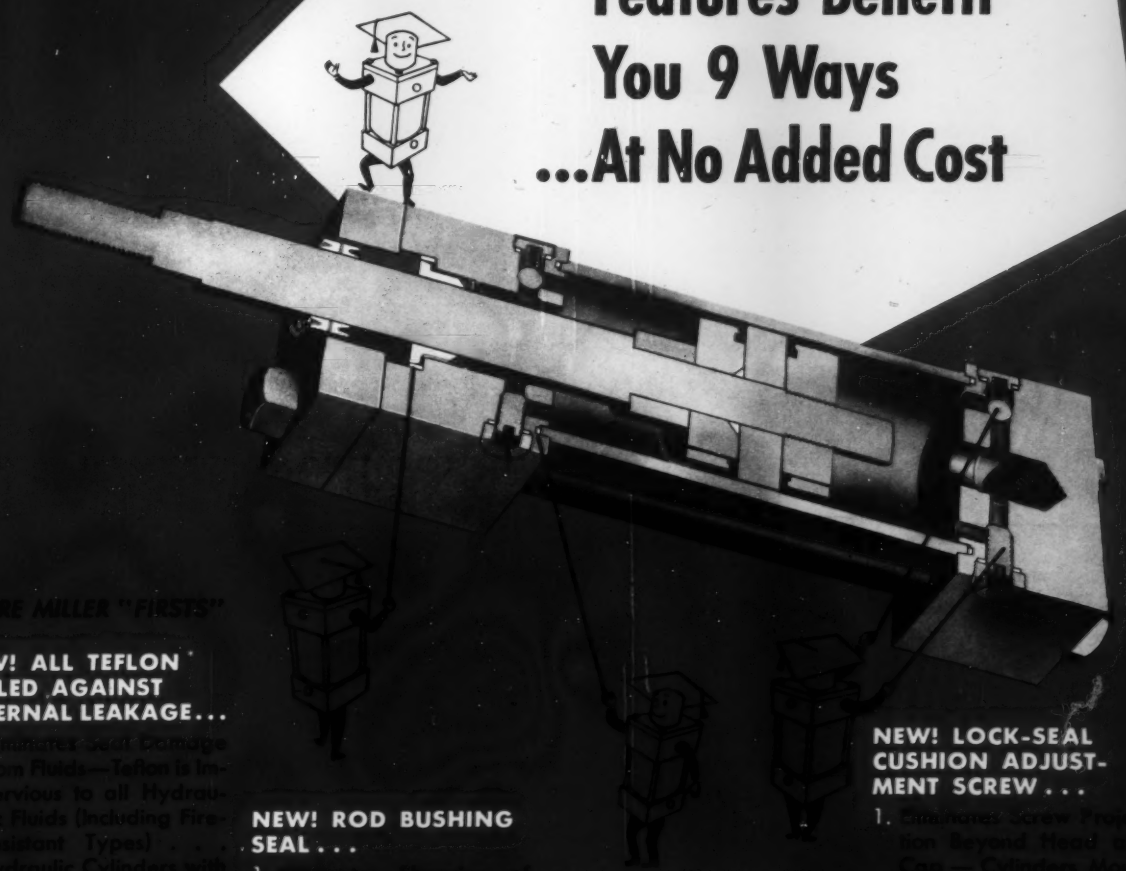
SHELL

Circle 441 on page 19

Circle 442 on page 19→

Miller®

4 New Hydraulic Cylinder Features Benefit You 9 Ways ...At No Added Cost



MORE MILLER "FIRSTS"

NEW! ALL TEFLON* SEALED AGAINST EXTERNAL LEAKAGE...

1. Eliminates Seal Damage from Fluids—Teflon is impervious to all Hydraulic Fluids (including Fire-Resistant Types) . . . Hydraulic Cylinders with Teflon Piston Cups Slightly Higher.
2. Eliminates Seal Damage from High Temperatures—Teflon Sealed Cylinders Operate At —100° F. to 500° F.

NEW! ROD BUSHING SEAL . . .

1. Eliminates Shearing of "O" Ring in Re-Assembly.
2. Eliminates Extrusion of "O" Ring at Extreme Pressures.

NEW! SHEF SEAL AT TUBING ENDS . . .

1. Eliminates Shearing of "O" Ring in Re-Assembly.
2. Eliminates Extrusion of "O" Ring at ANY Pressure—Teflon Sealing Ring is Backed Up by Zero Clearance Metal Shoulder.

NEW! LOCK-SEAL CUSHION ADJUSTMENT SCREW . . .

1. Eliminates Screw Projection Beyond Head and Cap — Cylinders Mount on Any Side.
2. Eliminates Manual Sealing and Locking After Flow Adjustment—Teflon Seal is Self Regulating and Self Locking.
3. Eliminates Accessibility Problems—Cushion Screw Interchangeable with Ball Check Position—Adjustable Through Small Wrench Hole Drilled in Interfering Machinery.

*du Pont trademark for its tetrafluoroethylene resin

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Turn Page For Cross Section Of SHEF SEAL

OTHER MILLER QUALITY FEATURES

- Case-Hardened Chrome Plated Piston Rod
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers
- Interchangeable Square Design

Miller FLUID POWER DIVISION

2006 N. Hawthorne Ave., Melrose Park, Ill.

HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

Announces a New Space and Price Saving Hydraulic Cylinder Line

SAVE UP TO 76% OF COST

Heavy Duty Model LH—Same Size As Ordinary Gasket Type Square Design Low Pressure Cylinders

BORE	NORMAL RATINGS	NON-SHOCK INTERMITTENT RATINGS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

MORE MILLER "FIRSTS"

Announces 50% More Power Per Cylinder Dollar

with Extra Heavy Duty

3000-5000 PSI MODEL H

HYDRAULIC CYLINDERS

Same Price and Mounting Dimensions as Miller 2000-3000 PSI Hydraulic Cylinders.

BOTH LINES MADE POSSIBLE BY SHEF SEAL

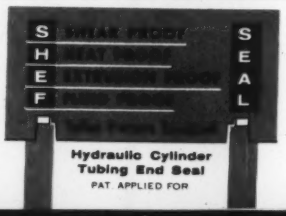
Copyright 1957—Fluid Power Corporation

Miller - FLUID POWER DIVISION

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

OTHER MILLER QUALITY FEATURES

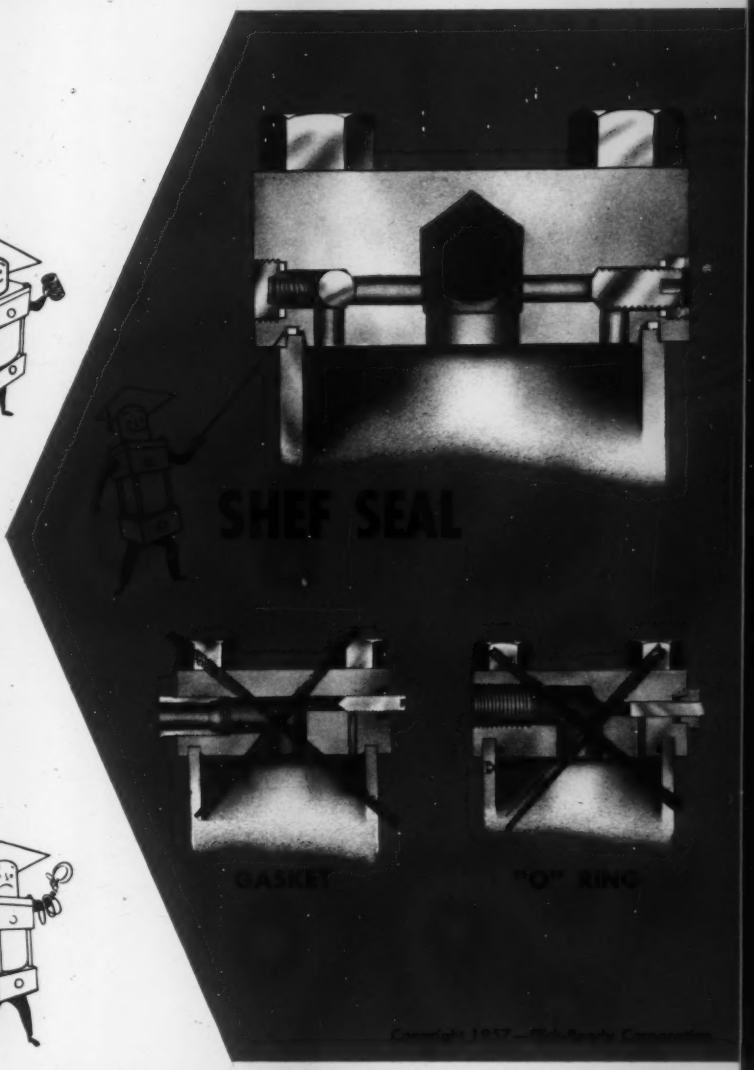
- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers



SHEF SEAL Obsoletes All Other Hydraulic Cylinder End Seals . . . *at no added cost*

HAS EVERY ADVANTAGE

1. Pressure Energized—Sealing Effectiveness Increased with Pressure.
2. Zero Metal-To-Metal Clearance at all Pressures Gives You Perfect Seal Backup. Sealing Ring Cannot Extrude.
3. Simplified Servicing. No "Blind" Assembly. Sealing Ring Cannot Shear.
4. Teflon* Sealing Ring Withstands All Hydraulic Fluids at Temperatures from —100° F. to 500° F.
5. Head and Cap Axial Movement Does Not Destroy Sealing.
6. Allows Air Bleed In Head and Cap for Remote or Automatic Bleeding.
7. One Sealing Ring Cross Section Dimension For All Cylinder Sizes—Supplied On Convenient Spools.
8. Zero Metal Backup Clearance Eliminates Dangerous Leaks and Spurts of Fluid Due To Seal Failure.



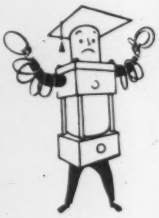
NONE OF THESE DISADVANTAGES

GASKET CONSTRUCTION

1. Unpredictable Results—Leaks and Blows Even at Low Pressures.
2. Outlawed by J.I.C. Eight Years Ago.
3. Seal Failure Causes Dangerous Leaks and Spurts of Fluid. Creates Unnecessary Fire and Safety Hazard.

"O" RING CONSTRUCTION

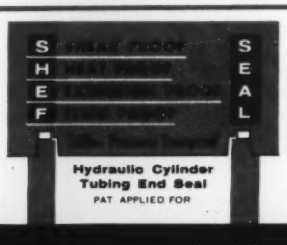
1. High Pressures and Shock Loads Expand Tubing—Increase Clearance and Cause Extrusion.
2. Blind Assembly Can Shear Sealing Ring—Difficult Servicing.
3. Seal Failure Causes Dangerous Leaks and Spurts of Fluid. Creates Unnecessary Fire and Safety Hazard.
4. Requires Large Inventory of "O" Rings
   —For Servicing Variety of Cylinder Bores.
   —For Special Synthetic Rubber Compounds To Meet Ever Changing Fluid and Temperature Needs.



*du Pont trademark for its tetrafluoroethylene resin.

SHEF SEAL—*Another Miller "First"*

When you buy Miller ... You buy extra years of worry-free Cylinder performance ...at competitive prices



OTHER MILLER QUALITY FEATURES

- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers

FLUID POWER DIVISION

Turn Page For More About MILLER

All Teflon Sealed —Perfect Sealing for Hydraulic Cylinders

HAS EVERY ADVANTAGE...

Teflon—As Static and Dynamic Seals

1. Impervious to Every Hydraulic Fluid Including Fire-Resistant Types.
2. Seals Perfectly in Cylinders at Temperatures from —100° F. to 500° F.
3. Can Be Molded Into Shapes That Have Zero Leakage—Hold Pressure Indefinitely.
4. With Proper Design of External Seal Cavities, Teflon Can Be Included *Without* Increasing Prices. Miller Provides Teflon for all External Seals at Prices Competitive with Ordinary Cylinders. Leather Internal Piston Cups are Standard (Teflon Cups Extra).

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•du Pont trademark for its tetrafluoroethylene resin.

When you buy Miller
You buy extra years
of worry-free
Cylinder performance
...at competitive prices

NONE OF THESE DISADVANTAGES

Synthetic Rubber— As Static and Dynamic Seals

1. Unsatisfactory Except When Used With A Limited Range of Hydraulic Fluids.
2. Even Uncontrollable Changes in Fluid Additives Often Destroy Seal.
3. Specific Compounds Needed for Compatibility with Specific Fluids Normally Used Today.
4. Normal Temperature Range Limited to 0° F. to 130° F. Slightly Reduced Life When Operated at 130° F. to 150° F. Greatly Reduced Life at 150° F. to 250° F.
5. External Leakage Causes Fire and Safety Hazards When Temperature or Fluid Destroys Seals.
6. "U" Type Seals Without Mechanical Retainer at Mid-Section Frequently "Roll" and Lose All Sealing Ability.

Resin Impregnated Leather— As Dynamic Seals Only

1. Is Compatible with Many—But Not All—Hydraulic Fluids and Additives Including a few Fire-Resistant Types.
2. Normal Temperature Range Limited to —60° F. to 130° F. Slightly Reduced Life When Operated at 130° F. to 150° F. Substantially Reduced Life at 150° F. to 250° F.
3. External Leakage Causes Fire and Safety Hazards When Temperature or Fluid Destroys Seals.

   Miller Uses Leather Piston Cup Seals for Internal Sealing... Standard Price (Teflon Cups Extra).

Piston Rings— As Dynamic Internal Seals

1. Most Piston Rings Allow Some Leakage.
2. Allow "Slip" or "Drift" of Piston Due To Leakage—Unsatisfactory for Many Applications.
3. Allow Varying Feed Rates Due To Leakage Because Of Viscosity Change During Startup—Unsatisfactory for Most Multiple and Automated Operations.
4. Allow Some Pressure Loss.
5. Chips and Dirt Enter Space Between Piston and Tube Causing Scoring —Especially During Startup.

All Teflon Sealed—*Another Miller "First"*

OTHER MILLER QUALITY FEATURES

- All Teflon Sealed Against External Leakage—Teflon Cups Extra
- Case-Hardened Chrome Plated Piston Rod
- Shear Proof Rod Bushing Seal
- Ball Check Interchangeable with Self Sealing and Locking Cushion Adjustment
- Rust Resistant Surfaces
- Teflon Oil and Dirt Wipers

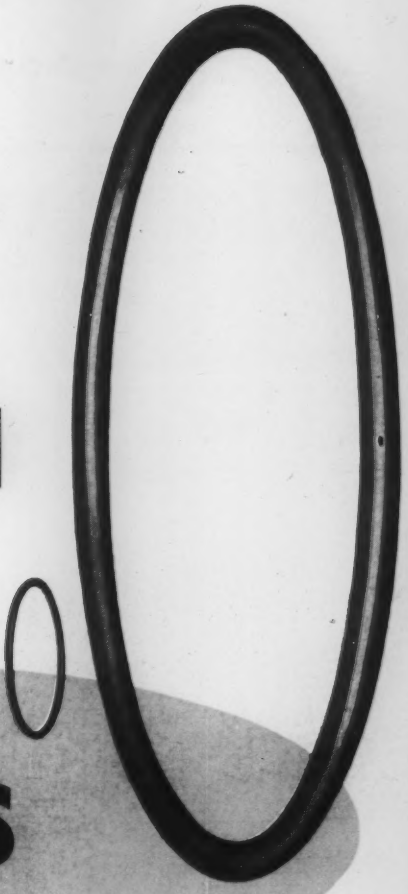
FLUID POWER DIVISION

2006 N. Hawthorne Ave., Melrose Park, Ill.

NOW

for the first time

LOW COMPRESSION SET



Butyl "O" RINGS

NEW

Another LINEAR first . . . a new, low compression-set Butyl Compound for use in "O" Rings. LINEAR Butyl Compound 7806-70 is a seal material that withstands compression set at elevated temperatures without being permanently deformed or losing its resiliency and its value as a seal. Also, Butyl withstands the chemical actions of the non-flammable phosphate esters such as "Skydrol", "Pydraul", "Celluflex" and "Lindol".

YET, PROVEN

Exhaustive tests, under method "B" of the ASTM, show this new LINEAR compound develops only 30 to 40% compression set after 70 hours at 212°F, as compared to the usual 70 to 95% set experienced with previous Butyl compounds. This unusually good resistance to permanent deformation, combined with a tensile strength of 2000 psi and an elongation factor of 275%, make this material an outstanding one for all "O" Ring applications and other molded shapes where Butyl rubber's excellent qualities are desirable.

Whenever you have a seal problem that is tough to handle—look to LINEAR for an answer. Write, or ask the local representative for complete information on LINEAR's new Butyl Compound 7806-70—today.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 443 on page 19

Up to 40% higher tightening torques keep a

—and only the combination of an UNBRAKO screw

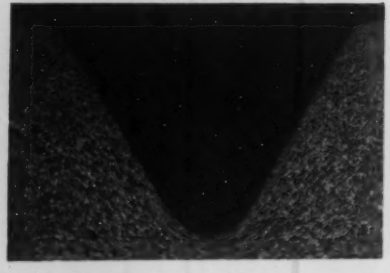
RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (Inch-Pounds)

SCREW SIZE	UNBRAKO	SET SCREW B	SET SCREW C	MINIMUM DIFFERENTIAL %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

The High-Torque UNBRAKO socket set screw is made to withstand the highest tightening torques ever used to seat a set screw—up to 40% higher than an ordinary set screw. But to take full advantage of this UNBRAKO feature you must have a key that can apply the force required to seat it without damaging the screw or snapping the key. The High-Titan UNBRAKO hex key is designed specifically to set a High-Torque UNBRAKO so that you can be assured of full *high-torque* performance every time.

Here's why a High-Torque UNBRAKO can be seated tighter—and stay put

UNBRAKO SET SCREW

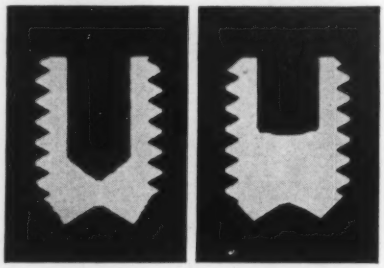


It has fully formed threads that make the whole screw stronger. The metal is compressed into the closely knit grain structure that you see in this illustration. The grain flow follows the contour of the threads. There are no straight lines along which shear can occur. The UNBRAKO retains its flow lines even when ground down to .010 in. below root diameter. Screws with cut or ground threads lose thread form at root diameter.

UNBRAKO SET SCREW

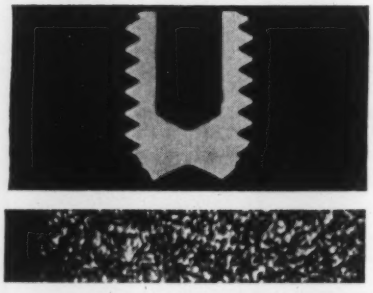
The High-Torque UNBRAKO has a radius in the socket corners. This eliminates the sharp corners where cracks start. It also distributes the stresses developed when tightening torques are applied. Ordinary socket screws have sharp corners which often crack when tightened even at lower torques than those recommended for UNBRAKO.

UNBRAKO SET SCREW **ORDINARY SET SCREW**



The High-Torque UNBRAKO has a deeper socket, which gives you more purchase with the wrench. Since more wrench can be put into the UNBRAKO socket, you can set the screw much tighter. And you won't ream the socket or round the corners of the wrench.

UNBRAKO SET SCREW

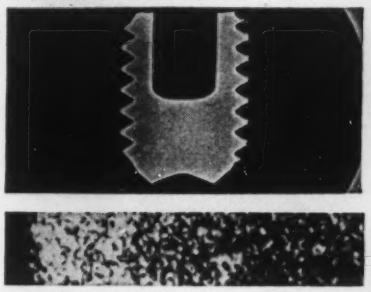


The High-Torque UNBRAKO is properly heat treated, kept clean. Its grain structure is uniform. It is free of decarburization. There's no danger of stripping the threads or shearing the point when tightening

High-Torque UNBRAKO socket set screw tight

and key assures full *high-torque* performance

ORDINARY SET SCREW



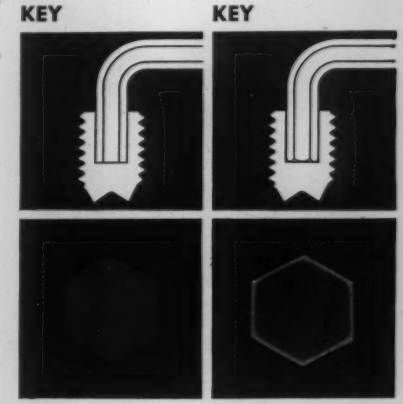
torques are applied. The ordinary screw is suffering from an overdose of decarburization; socket walls, threads and point are full of the telltale white spots that identify it.

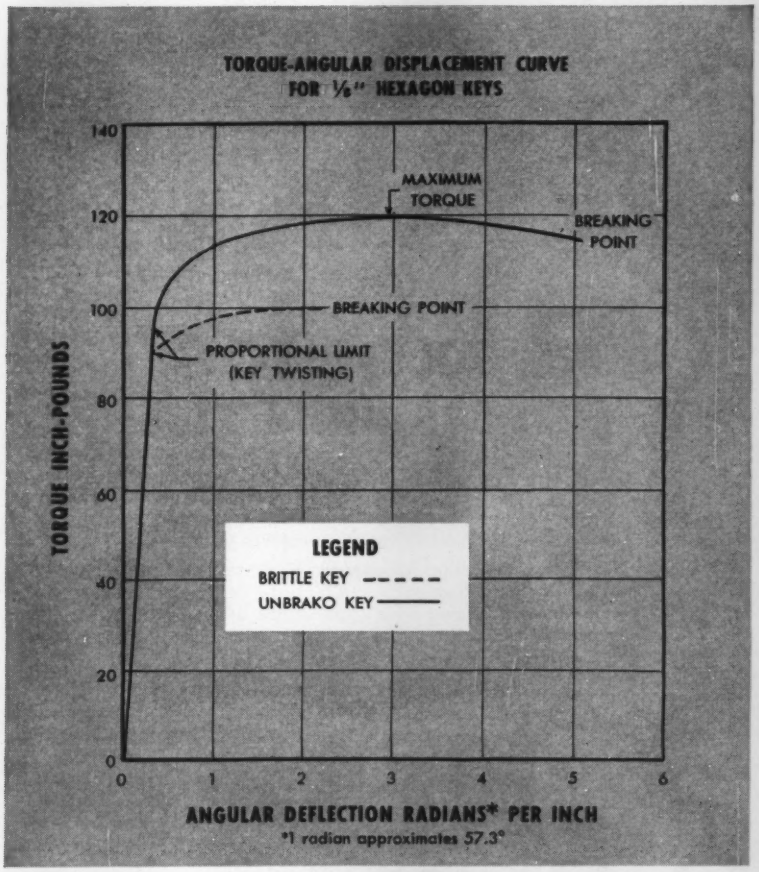
And here's why an UNBRAKO High-Titan hex key can be used to apply far more tightening torque to a High-Torque UNBRAKO socket set screw than is needed without damaging either the screw or the key.

The High-Titan UNBRAKO is not an ordinary hex key. It is a precision internal wrenching tool with high ductility, specially designed to assure full high-torque performance. It is made of special alloy steel bar stock, inspected magnetically and chemically to make sure that the material is flawless and of the specified properties. Its sides are flat and parallel. The corners, which exert torque on the inner walls of the socket, are sharp and tough. The bend is strong.

The High-Titan UNBRAKO is accurately sized across the flats and across the corners to insure snug fit and full wall contact. It won't ream or wear an UNBRAKO socket. The square cut end engages the full depth of the socket for greater tightening power. It gives you up to 25% more wrench engagement than a key with a chamfered end.

UNBRAKO KEY **CHAMFERED END KEY**





The High-Titan UNBRAKO hex key is heat treated in modern atmosphere-controlled furnaces. The surface is casehardened without decarburization. The extra hard surface gives the key longer life. And it retains its dimensional accuracy, is tougher and more ductile than ordinary keys. This torque-angular displacement curve for ⅛ in. hexagon keys distinguishes a High-Titan UNBRAKO from an ordinary key. The High-Titan UNBRAKO has a higher yield point and a higher breaking point—you can exert a much higher torque with it without snapping the key.

Be sure you get the full high-torque performance offered only by the combination of a High-Torque UNBRAKO socket set screw and a High-Titan UNBRAKO hex key. Both products are stocked by authorized industrial distributors. Ask the one nearest you for complete information. Or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

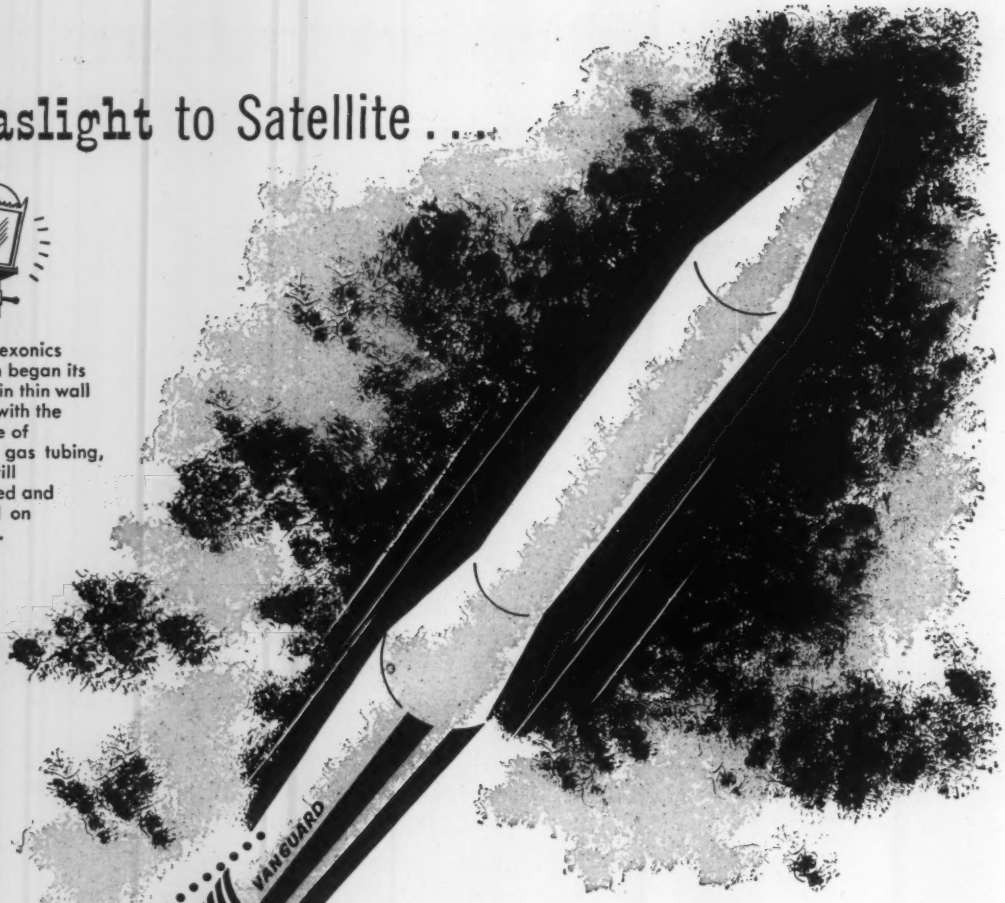
We also manufacture precision titanium fasteners. Write for free booklet.

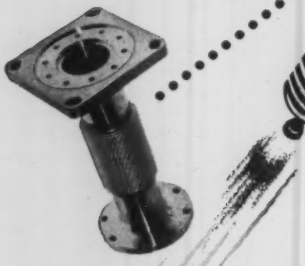
Unbrako Socket Screw Division **SPS** **Jenkintown, Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Cooper Precision Products • Standco Canada, Ltd. • Unbrako Socket Screw Co., Ltd.

From Gaslight to Satellite . . .

IN 1902 Flexonics Corporation began its experience in thin wall assemblies with the manufacture of "Kantleke" gas tubing, a product still manufactured and widely used on gas heaters.





IN 1957 IN THE HEART OF THE VANGUARD, a high performance flexible connector by Flexonics. Proofed at 1500 psi, it will go to work in the first stage of the earth satellite launching vehicle in the International Geophysical Year.

*Du Pont trademark, licensed by Resistoflex Corp.

10 plants to serve you in the United States and Canada

FLEXONICS
First in Fluid Flow

As a pioneer in the design and fabrication of flexible hose, connectors, ducting and related items, Flexonics Corporation is proud to be the supplier of critical assemblies for many of the nation's most advanced projects.

The unmatched know-how of Flexonics Corporation that led to this selection is available to help you. Your requirements will be met with applications incorporating the newest proven techniques and the most advanced thinking of the industry.

Included among Flexonics products are metal, synthetic and Teflon* hose . . . metallic bellows . . . aircraft components . . . piping expansion joints for low, medium and high pressures.

For engineering assistance or product application data—call or write, today

G-37

Flexonics *Corporation*

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 445 on page 19

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on the sale of new designs

Designers gain prominence through the effectiveness and saleability of their work. The sales appeal of stainless steel is a powerful tool for selling new designs. It has turned many design ideas into profitable products.

The recognized merits of stainless steel, such as strength and corrosion resistance, make it equally "right" for housewares, jet engine parts, or chemical equipment. These qualities plus a variety of finishes have put stainless into planes, trains, cars, cafeterias, and scores of other places.

For more facts about stainless steel see your supplier. For a free copy of "Stainless Steel in Product Design" write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

This 40-page book will give you important facts about selecting and applying stainless steel. Write for it today.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

A Two extension coil springs hold assembly against shaft.

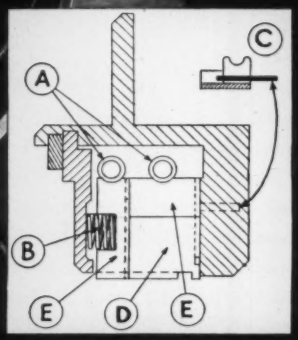
B Axial compression springs exert constant positive pressure toward the sealing face.

C Key and pin assemblies lock carbon segments against rotation.

KOPPERS CIRCUMFERENTIAL SEAL

PROVIDES UP TO 2000 hrs. OF PERFORMANCE

CAN USE LESS THAN 5 h.p.



D Flexible sealing segments permit seal to achieve same circularity as shaft.

E Straight-cut joints are covered and sealed by segmental cover ring and segmental back ring.

A number of finite joint gaps allow for ring wear.

Koppers Circumferential Seal is a segmented carbon seal ring with straight-cut joints. Its design can be modified to use step type joints or step seal joints. Primarily a gas seal, the Koppers Circumferential Seal will seal liquids if the geometry of the shaft mating faces is changed.

Koppers Circumferential Seals are one of a large variety of seals designed and manufactured by Koppers for every industrial use. Because of this complete line, Koppers can recommend, without bias, the seal best suited to your specific application. And Koppers continuous development and testing of new designs and new materials assure you of the most advanced, most efficient seals for your purpose. If you have a sealing problem, write to the KOPPERS COMPANY, INC., Metal Products Division, Piston Ring and Seal Department, 2309 Scott St., Baltimore 3, Maryland.

Engineered Products
Sold with *Service*

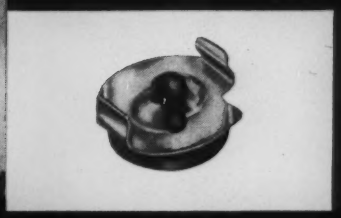
KOPPERS

MECHANICAL SHAFT SEALS

Circle 447 on page 19

DOT THREAD CUTTING FASTENER
HOLDS TIGHT TO CURVED SURFACES

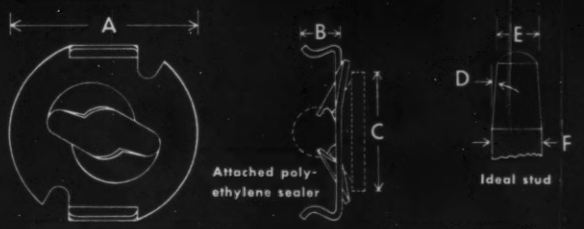
- Low Cost
- Re-Usable
- Self-Locking
- Vibration-Proof
- Spring Take-Up



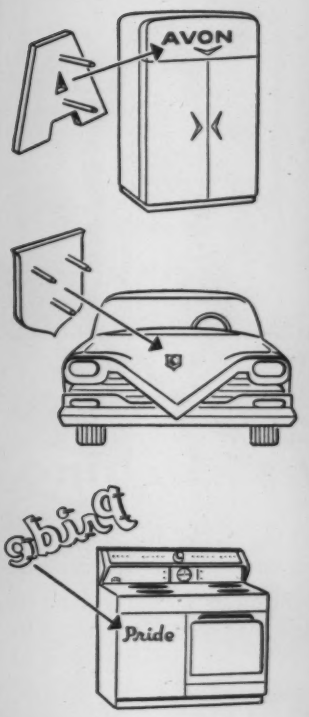
Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT'S unique T.C.F. can be used in many other applications which require a spring take-up fastener that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer precedes the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available in quantity, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.

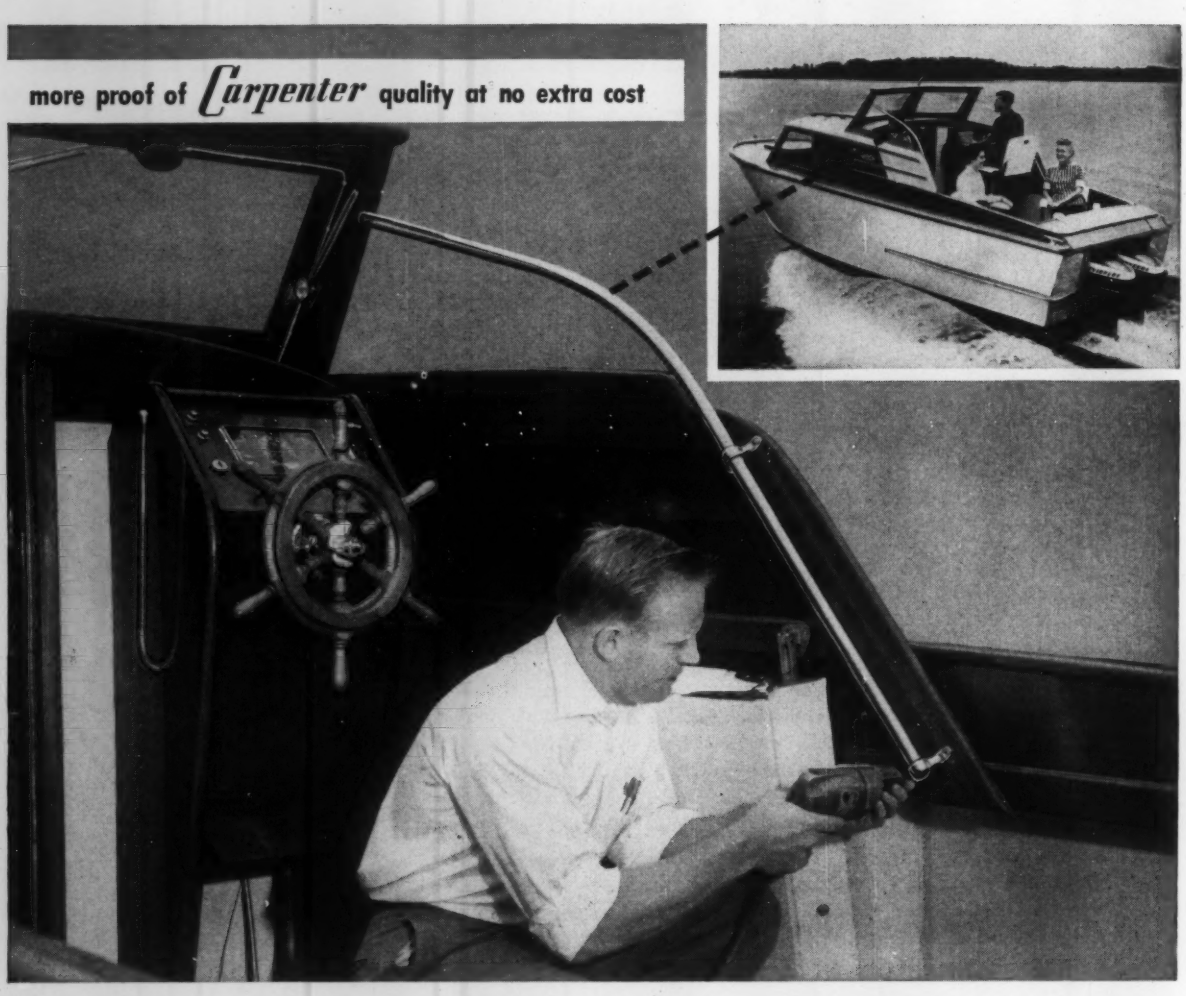


Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6°/4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6°/3°	.160 .150	.192 .184	20 - 30 Inch lbs.	400 lbs.
1/4"	.875	.260	.625	6°/4°	.190 .180	.255 .245	25-30 Inch lbs.	500 lbs.



DOT T.C.F.
Patent Pending

UNITED-CARR FASTENER CORPORATION



Costs cut 25% on boat handrails by switching to *Carpenter* Stainless Tubing

● Note the reasons why a 1957 line of 22-foot pleasure cruisers features gleaming stainless steel handrails:

By changing to Type 302 Carpenter Stainless Tubing, time and costs of making the handrails has been reduced 25%. Better bendability, improved appearance and no plating to peel in marine atmosphere are other important advantages gained. The tubing is 1″ O.D. with 18-gauge wall thickness, and 180-grit polished finish, in 22-ft. lengths.

The boat builder reports that Carpenter Stainless Tubing bends around a special 30-in. radius jig with less spring-back and shows no kinks or marks from bending. For maximum attractiveness, it is polished on a 240-grit and buffed.

Get this cost-saving quality and workability of stainless tubing for your products or equipment by calling your nearby Carpenter Distributor. He's at your service on over 30 different stainless and specialty analyses in a wide range of sizes, gauges, shapes and finishes . . . for pressure, mechanical, structural and sanitary services.

MEMBER

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

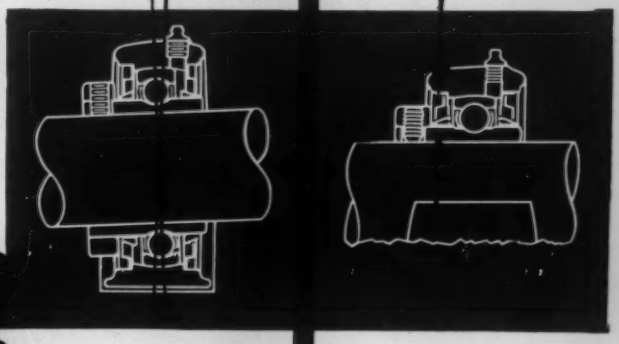
Stainless Tubing & Pipe

Circle 449 on page 19

Self-aligning SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

14,338-A

LINK BELT

THE SYMBOL OF QUALITY — LB — LINK-BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

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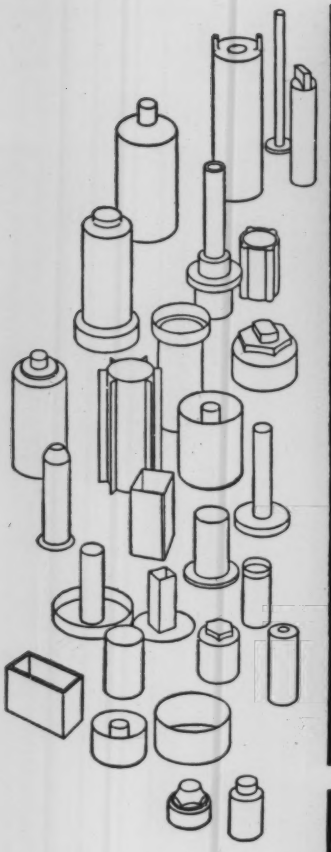
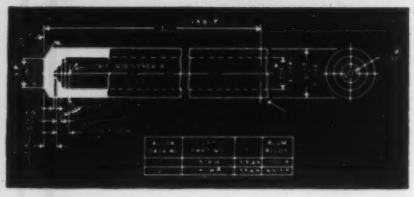




small part, big saving–thanks to an **ALCOA IMPACT**

This interesting little Alcoa® Impact does a big job in a thermostat control designed for use with electrically heated appliances. It is the probe which forms the sensing element of the thermostat. Changes in the length of the probe control the opening and closing of the unit's electrical contacts.

Considering the close tolerances and extreme length-to-diameter ratio of 15 to 1, most designers would visualize this part as a screw machine product. Fabricated on a screw machine, it would call for a drastic deep-drilling operation into solid bar stock, plus a further chamfering and cutoff operation on the closed end. In short, it would be a fairly expensive and troublesome part to produce.

As an Alcoa Impact, however, just one punch of the press delivers a complete, close-tolerance part in a fraction of a second. The only finishing operation required is the cutting of the piece to the exact length required. The production economies are easy to see. And remember, just about any closed-end tubular part or cup-shaped part can be produced by impact extrusion. No matter how intricate, if it can be made as an Alcoa Impact, it is fabricated in one smack in a split second.

If you think you should be considering the possibility of using an Alcoa Impact, send for our helpful design manual, *Alcoa Impacts—Metal in Motion*. If you have a problem you want to talk about right now, call your nearest Alcoa sales office, (you'll find it listed under "Aluminum" in the Yellow Pages of your telephone directory) and an Alcoa sales engineer will be glad to help you out. Aluminum Company of America, 1991-J Alcoa Building, Pittsburgh 19, Pa.

Some Impact Rules of Thumb—

Check your problems against this list:

1. Parts requiring hollow sections—either tube or cup-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to ±0.005".
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

ALCOA ALUMINUM IMPACTS

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Circle 451 on page 19

LONGER SOLENOID LIFE...

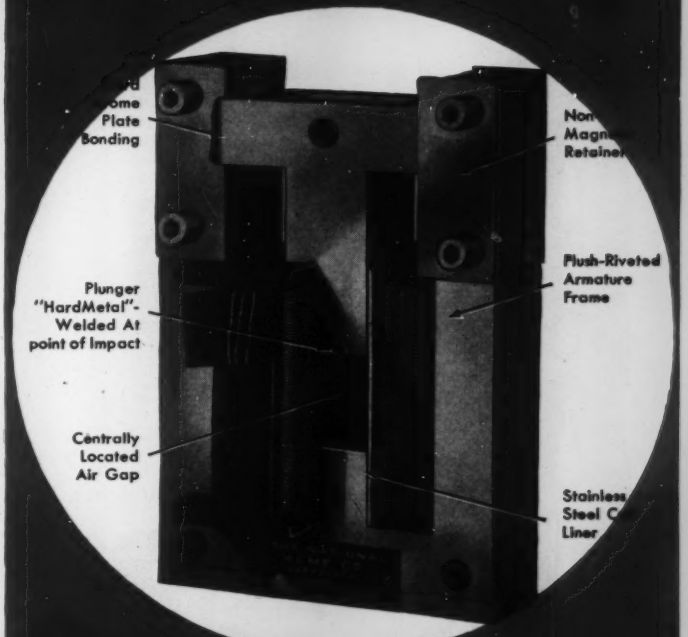
with NAMCO'S exclusive "HARDMETAL"-welded plunger bonding

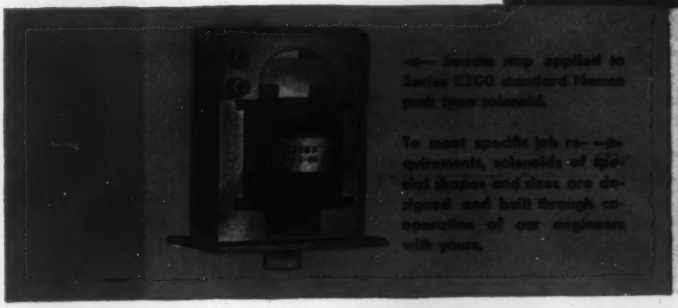
Standard or Custom Models To Fit Your Design

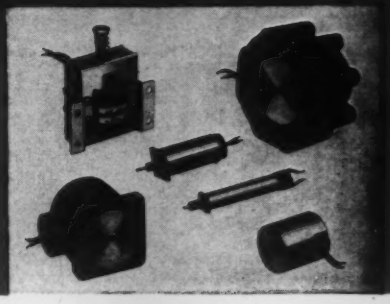
"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

Standard "HardMetal"-Welded Solenoids are furnished push or pull type in sizes with ratings from 2-1/2 to 21 pounds at 1/2" stroke and from 2 to 25 pounds at 1" stroke.







Ask us to send a National Acme Representative to discuss your problems, or if you want more information first—send for BULLETIN EM-52.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL ACME COMPANY • 188 EAST 131ST STREET • CLEVELAND 8, OHIO

Circle 452 on page 19

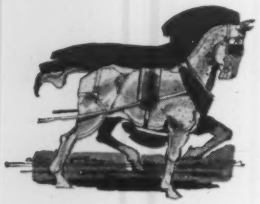
When your power drive considerations involve:

HEAVY LOADS

Rex Chabelco Chains are your economical choice. These are the "work horse" chains...designed and built with extra strength and ruggedness. They have carefully hardened surfaces for *longest* wearing life...inner ductility to resist the heaviest shock loads.

TOUGH OPERATING CONDITIONS

Rex Chabelco Steel Chains operate efficiently under toughest operating conditions. Planned tolerances and "built-in" clearances between working parts enable Chabelco to withstand effects of dust, dirt, heat and abrasion...last longer than any other type of chain.



SLOW TO MODERATE SPEEDS

As a "work horse," Rex Chabelco operates most efficiently in the slow to moderate speed range. Their pitch is longer than chains designed for higher speed service and, within its range, Chabelco assures lowest cost per dollar of h.p. transmitted. They can be used with cast tooth sprockets, an important cost-saving advantage.

choose REX® Chabelco Chains for lowest cost

Within their broad service range, Rex Chabelco Steel Chains are your economical choice for power drive service. Naturally, they are *not* the answer for every drive. Because they are designed for "work horse"...not "race horse" ...service, they are not particularly suitable for ultra high speed service. But for heavy loads, slow to moderate speeds, and tough operating conditions, they are by far your best choice. Why not have a CHAIN Belt District Sales Engineer explain why you'll get so much more with Chabelco. Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.

If you would like a subscription to *Rex World*, CHAIN Belt's informative picture magazine of product application, please send your name and address.

CHAIN BELT COMPANY

Your ONE source for a complete line of power drive and conveyor chains, sprockets, roller bearings, flexible couplings.

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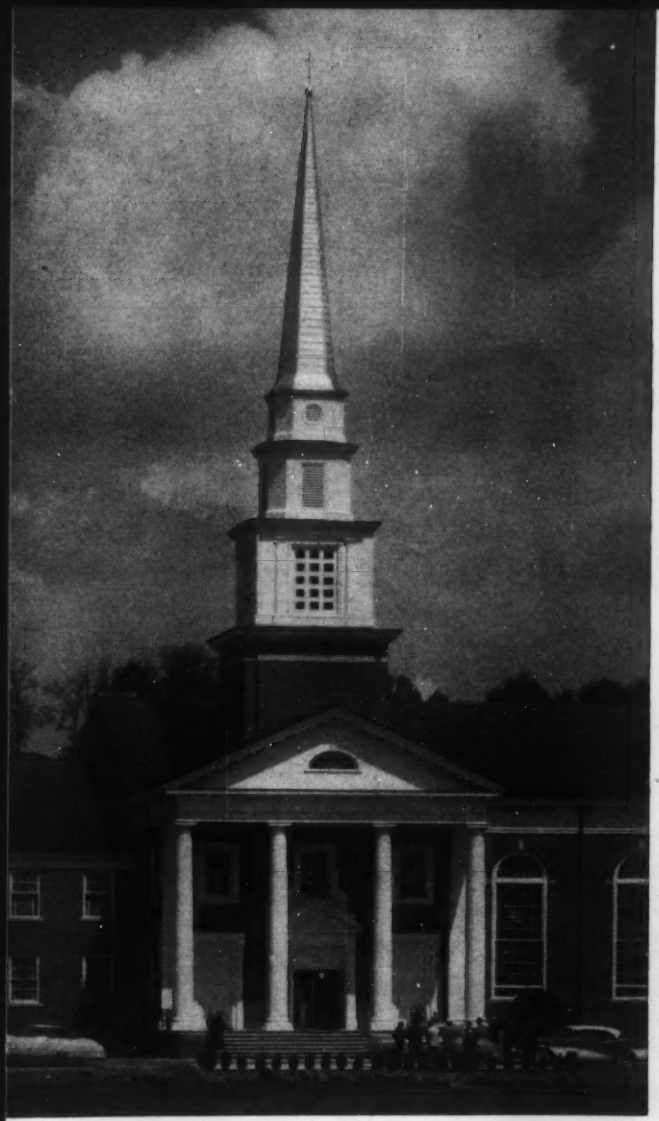


NOTHING *can equal*
Stainless Steel
in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

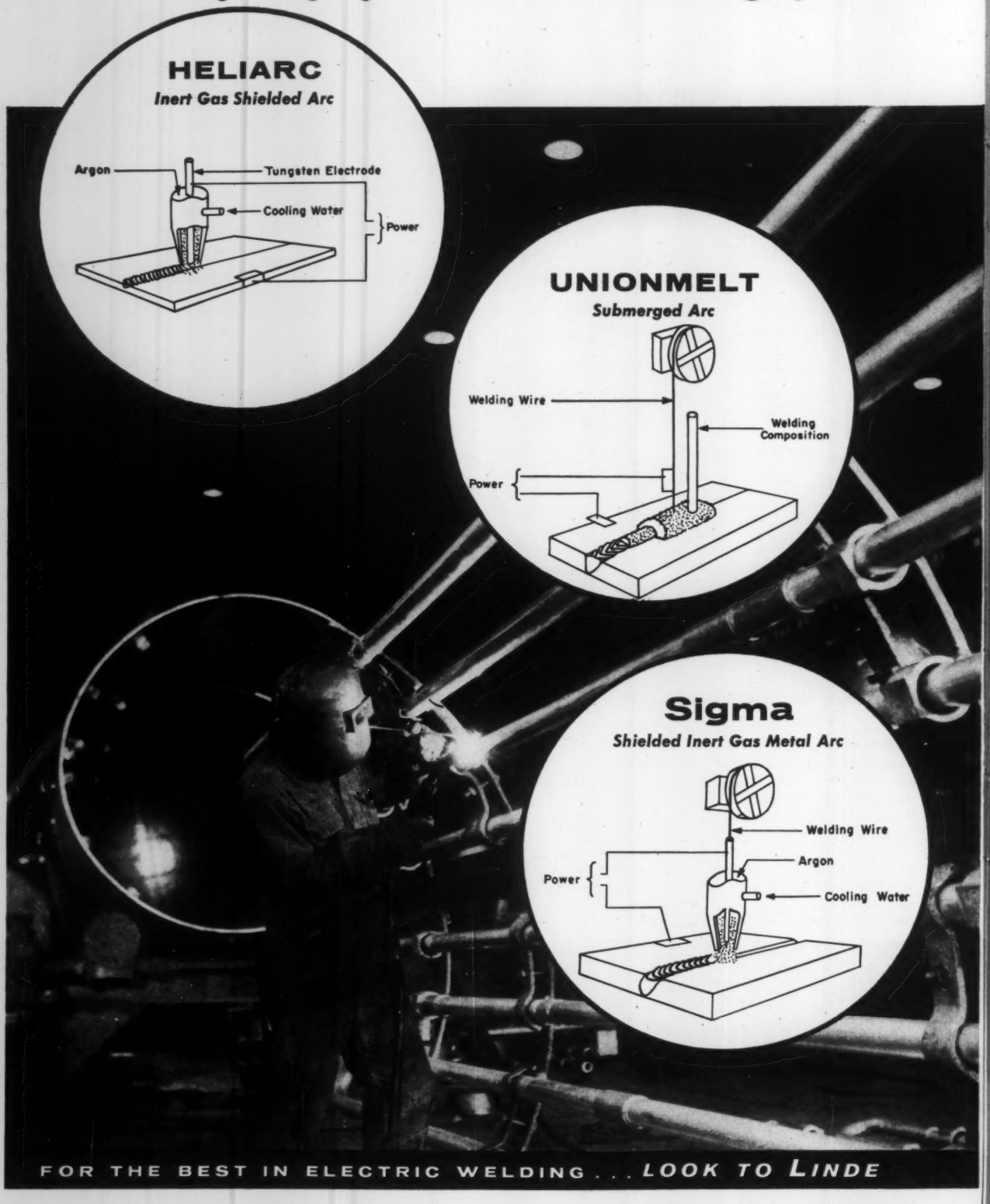
UNITED STATES STEEL

◀ **FOR BEAUTY.** Stainless Steel shingles in diminishing sizes create a beautiful, gleaming steeple for the State Street Methodist Church in Bristol, Virginia. Architect Allen Dryden, of Kingsport, Tenn., specifies Stainless Steel for jobs like this to assure lasting beauty, protection from weather and freedom from maintenance. This spire is sheathed in Type 302 26-gage Stainless Steel, and the cross is built of Type 302 Stainless bars. Construction details were engineered by Overly Manufacturing Company, Greensburg, Pa., who also fabricated and erected the steeple.

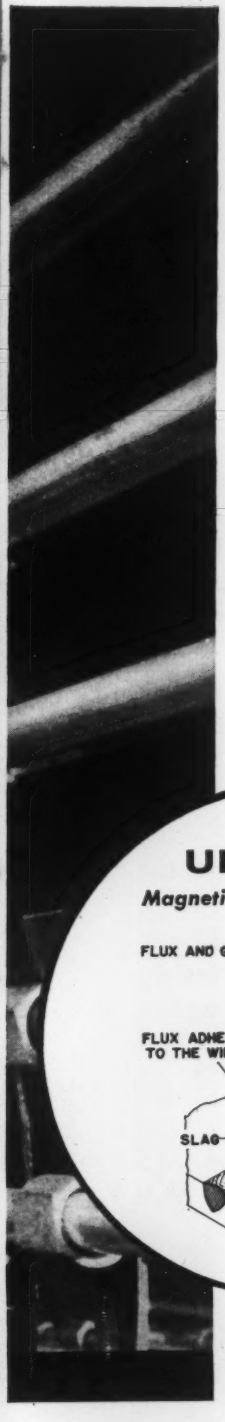
FOR FLEXIBILITY OF DESIGN. In this "Cold-Zone" cooling-storage milk products tank, made by Damrow Brothers Company, Fond du Lac, Wisc., Type 304 10-gage Stainless Steel was used for the smooth, easy-to-clean inner wall. Again Stainless Steel—this time Type 304 16-gage—was used for the dimpled outer wall which is stave-welded to the inner shell. This unusual design of dimple size and arrangement gives proper baffling and velocity to the refrigerant as it passes through the cooling area. Stainless Steel provides greater sanitation, durability, long life, strength and—the flexibility necessary to make this design possible.

FOR DURABILITY. The Master Combination Padlock, designed for school locker room use and built by Master Lock Company, Milwaukee, Wisconsin, features a double-case construction—with Type 430 Stainless Steel used for the outer case. This Stainless Steel design makes it one of the strongest padlocks available. In addition to increasing the lock's durability, Stainless Steel also adds to its sales appeal and to its resistance to the corrosive atmospheres of damp locker rooms. The springs, too, are made from USS Stainless Steel—Type 304 Ameroxide coated wire.

For any of your welding jobs



. . . LINDE can supply the *right method!*



• *Inert gas shielded arc welding—*

HELIARC Apparatus for inert gas shielded arc welding, using a tungsten electrode and a shield of LINDE argon, is tops for joining hard-to-weld commercial metals. On stainless steel and aluminum, HELIARC Welding is fast and clean, producing high-quality welds that resist corrosion. HELIARC Welding eliminates costly grinding and finishing, making it a valuable method for quantity production of hard-to-weld metals.

Submerged arc welding—

Shapes made of materials ranging from light gage to heavy plate, adaptable to mechanization, can be most economically joined by UNIONMELT Welding. It is used on low and medium carbon steels and alloy steels, including those containing chrome and/or nickel. UNIONMELT Welding is also used extensively for resurfacing metal, providing extra wear and corrosion resistance. UNIONMELT Welding is fast and inexpensive on production jobs.

Shielded inert gas metal arc welding—

One of the most versatile welding methods is Sigma Welding. LINDE's Sigma apparatus, using a shield of LINDE argon, is ideal for manual welding of commercial metals ⅛ in. or more thick, and for automatic operation on lighter gage metals to .050 in. Highest quality welds can be made on aluminum thicker than ⅛ in. at speeds up to 16 inches per minute. Build-up and surfacing jobs are also improved by using LINDE's Sigma welding method.

New! Magnetic flux gas shielded arc welding—

UNIONARC Welding, LINDE's most recent development in electric welding, is an extremely fast method for welding mild steel. This method employs a continuously-fed, bare steel wire electrode, magnetically coated with flux conveyed in a stream of carbon dioxide shielding gas. Manual welds can be made easily in any position—vertical, overhead, downhand—with no stops to change electrodes. The speed, versatility, and ease of operation of of UNIONARC Welding brings costs down 25% to 65% below those of manual covered electrode welding. Clean, smooth, high-quality welds are provided, even in the presence of moderate amounts of rust, scale, and moisture.

Engineers at LINDE have been designing, developing, and testing electric welding methods and apparatus for many years. Help on any welding method is yours for the asking. You can improve your work and cut production problems by taking advantage of LINDE's experience. For data on UNIONARC Welding or any other electric welding method, call the LINDE office nearest you.

LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

Linde
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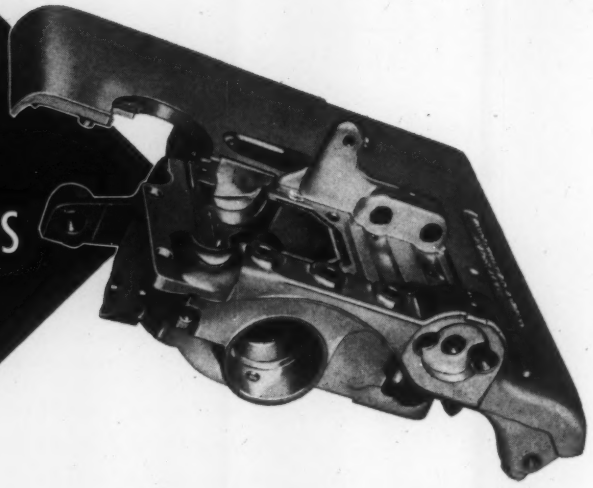
There's a Good Reason

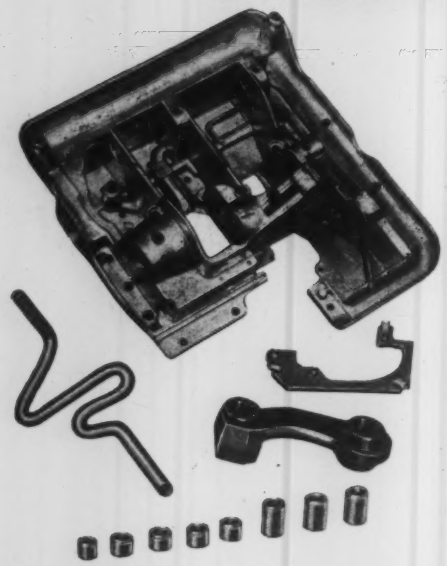
WHY ZINC DIE CASTINGS

are so widely used –



at WILLCOX & GIBBS

it's COMPLEXITY



With eight knurled and threaded steel bushings, a steel bracket, a large, double, bearing frame, and a copper tube cast into the top frame as inserts, this is probably one of the most complicated ZINC Die Castings ever to come out of a die caster's shop. The result is COMPLEXITY with a purpose, and ZINC Die Casting takes complexity for granted.

This unbelievable complexity of shape was readily achieved in this sewing machine top frame through a single ZINC Die Casting. Willcox & Gibbs engineers incorporated features which would support dozens of critical parts to operate a mechanism moving at 5,500 rpm with incredibly fast starts and stops—and without vibration.

This rugged commercial sewing machine has to meet high performance demands for seaming, hemming, edging and serging operations at lightning-fast speeds—day-in, day-out utility—for fifteen years and more. Only ZINC Die Casting could provide these exacting requirements.

All sides of this top frame have numerous cored openings (the cores being pulled in four directions) that simplify assembly and help to make the "Superlock" sewing machine so efficient. There are many advantages in this ZINC Die Casting that may provide answers to some of your production problems. Send for our free folder "Zinc Die Castings" and then see a commercial die caster.

THE NEW JERSEY ZINC COMPANY 160 Front Street, New York 38, N. Y.

The research was done and the Zamak die casting alloys were developed with

HORSE HEAD SPECIAL (99.99 + % Uniform Quality)

ZINC FOR DIE CASTING ALLOYS

MACHINE DESIGN
September 5, 1957

The Vital One Per Cent

IF YOU don't understand it, oppose it" is supposed to be a devastating commentary on the intelligence of those who don't immediately accept our own brilliant ideas. But the attitude, like that of the man from Missouri, has its merits.

Management faced with a big decision on a new product idea, for instance, has a right to insist on enough facts for a full understanding of the problem. What facts management needs, and how to go about getting them, are detailed in Phil Marvin's penetrating article beginning overleaf.

In its insistence on being "shown," management has been increasingly willing to spend money on that aspect of the design function usually referred to as R and D. Research is the fact-gathering part and development is the idea-proving part. Getting the facts and intelligently evaluating them can save untold dollars that might have been spent on fruitless development; hence today's big emphasis on research.

Research and development, in a sense, represent an effort to bring some of the elements of genius into an organization. Carlyle said genius is "a transcendent capacity for taking trouble." Edison expressed the same thought more earthily by describing genius as "one per cent inspiration and 99 per cent perspiration."

But there is danger of being carried away to the point where R and D are regarded as a panacea—spending time and money where the real need is for good solid thinking. It is all too easy, as Dr. Marvin puts it, to substitute mechanical effort for more difficult and less noticeable mental effort. Edison's 99 per cent is worthless without that vital, less noticeable, one per cent.

Colin Carmichael

EDITOR

Screening and Appraising
NEW-PRODUCT IDEAS

Impartial appraisal of proposed new products is one of the most difficult steps in a planned product-advancement program. Fourth in a current group, this article outlines the six steps involved in screening and appraising. The data necessary for realistic decisions are given, along with information on how to collect, correlate and use them.

AFTER time and money have been spent developing what later turns out to be the wrong product, it is too late to do much about it. On the other hand, care taken in screening and appraising potential new products can eliminate costly failures. It is impossible to calculate the full cost of a single product failure. Involved are both direct costs of items such as development expense, and indirect costs of such intangibles as lowered morale. Beyond these direct and indirect costs is the loss of profits that more than likely would have accompanied a successful new product.

Another aspect is important. Not long ago an executive remarked, "We have never introduced a new product that wasn't a success." His firm is to be congratulated if it has not passed over better products—products that would have been even more successful than the ones offered. Unrealized profits represent losses just as real as any other financial loss.

Responsibility for incurring economic losses can not be escaped by inactivity. Procrastination in selecting new products for development hardly reflects business acumen. We all know of corporations that have been shelving ideas for generations since the original founder built the corporation. A few years of such inactivity in planning and developing new products can mean loss of the most hard-won industrial position.

Developing ideas for new products is a big job in itself. To appraise and screen these ideas is an especially big job. Few corporations have the resources to develop every idea that comes into their possession, even if all of the ideas are good ones. Those responsible for planning product programs cannot escape responsibility for the vital operations of screening and appraising.

Selecting the Basis for Decisions: When one begins to ask questions about the mechanics by which particular ideas are selected for further development work, difficulty is frequently encountered. Many times we learn that ideas are selected on the basis of intuition or hunch. When attempting to probe the depth of intuition and hunch, we usually encounter mental fogginess. Those who are successful find much of the so-called "intuition" rests on a basis no firmer than a coin-tossing decision, backed up only by opinion and force. In sharp contrast with decisions of this caliber is the action taken by those who have a highly developed fact-gathering process and an analytical procedure for screening and appraising ideas.

Some have been extremely successful in gambling on ideas for new products—but the risks involved in such gambles are much too great for sound long-range planning purposes. Admittedly, most business decisions incorporate certain elements of gamble, but there is no valid reason for extending the gamble into areas where decisions can be based on facts.

Six Steps to Decision

A systematic appraisal program for new-product ideas encompasses six basic steps:

1. Clearly define the product concept.
2. Screen out ideas that are unacceptable to management.
3. Survey the patent picture.

By **PHILIP R. MARVIN**
Manager, Research and Development Div.,
American Management Association
New York

Photo, courtesy Boeing Airplane Co.

4. Investigate technical-economic aspects.
5. Review the literature.
6. Appraise and evaluate.

Product programs have failed because a single step in this process was overlooked. Each step, and the order in which they are taken, is important. Each step must be given careful and considered attention to provide basis for the next.

As product ideas are accumulated, they should be translated into product concepts. Preparatory to evaluation, each idea should be given definition in the form of a descriptive title and a concise statement of the scope of the idea application.

Product-Concept Statement

Points to be covered by the statement of the product concept include:

1. What the new-product idea contributes by way of new or improved function or lowered cost.
2. How this contribution is accomplished.
3. Why it is done in the selected manner.
4. The alternatives that exist.
5. Why the proposed method is selected.

A clear definition of the product concept establishes parameters for evaluation of the idea. At this point, definition is given to the idea. Prior to this, the product idea has been a nebulous thing. To be considered further, the idea must be put in a form understandable to others who may make valuable contributions to its success.

Presentation of good ideas may encounter closed minds if not done properly. The individual who initially develops an idea has usually given it a lot of thought. In his own mind, he has asked and answered many questions before putting his personal stamp of approval on the idea. He should not expect others to accept the idea without the benefit of this background of exploratory analysis.

A full statement of the product concept is necessary for initial acceptance. In addition, further preliminary analysis will rest substantially on the statements of the product concept. Further qualification of the idea will be needed as the screening process unfolds, but the product concept should anticipate as many of these questions as possible.

Screening Nonacceptable Ideas

Management generally has more or less well-defined interests. To be acceptable, proposed products must fit the pattern. An idea may be unacceptable simply because management is interested in a different line of business. For example, a control-equipment manufacturer turned down a rather well-defined idea for a revolutionary water softener on one occasion, and an idea for a new machine tool on another occasion, because the proposals represented radical departures from the established business.

Impractical Ideas: Snap judgment underlies the reaction to many new ideas. It is only human to substitute opinion for fact. Fact-gathering is a time-consuming process calling for highly developed skills. It is much easier to think along established product lines, leaving the job of big thoughts to big men. One of the easiest ways out is to label an idea as impractical.

The risk associated with rejecting product ideas on this basis is that further analysis might re-

veal inherent value that has been overlooked, possibly a number of times. Conversely, it is seldom possible to investigate every product idea thoroughly.

In a preliminary screening of product ideas, compromise based in part on guess and in part on intuition, usually comes into play. Ideas judged to be impractical may be impractical only relative to a particular time. At an earlier date the rejected idea may have had merit, or with changing technology or shifts in consumer patterns, the idea might be a good one. Nylon carriage whips would have been salable 100 years ago. Today, the idea doesn't seem to hold much promise. Baby-bottle warmers for space ships do not seem practical at the moment—but in 50 years they may be. The significance of the words practical and impractical is often found in the date mark of a product.

Corporate Interests: The scope of established corporate interests is limited by management thinking and by the established legal parameters that govern the activities of most businesses. The articles of incorporation contain a statement of the purposes of the corporation. The stated purposes have a direct bearing on product programs. Corporation charters may, of course, be amended, but such action must be explored by the corporation's attorneys prior to any large expenditure of time or money on ideas falling outside the stated purposes of the corporation.

In this connection, it is interesting to note that the general provisions as to the purposes of the corporation are sometimes stated in language broad enough to cover practically all kinds of business. One corporation, for example, is empowered to buy, sell, produce, manufacture, and dispose of all kinds of goods, wares, foods, potables, drugs, merchandise, manufactures, commodities, furniture, machinery, agricultural tools, supplies and products, and generally to engage in and conduct any form of manufacturing or mercantile enterprise not contrary to law.

In sharp contrast, the stated purpose of another corporation is limited to the manufacturing of lampblack, carbon black, gas black and kindred tar-oil products and to buy and sell the same. Both point to the importance of knowing the scope of the legal purposes of the corporation.

No idea should pass initial screening that management will not stand solidly behind. This is assuming, of course, that the idea passes further scrutiny without any significant negatives. Ideas passing the initial, superficial appraisal are judged acceptable as additions to the product line. Beyond this, further analysis is necessary to establish the practical merit of the idea on a profit basis. Ideas selected will later be subject to critical inspection.

At this point, ideas are sifted to remove from further consideration those that do not have management acceptance. The importance of this step is often lost in the enthusiasm for the new and novel.

Effect of Patents

It costs more to establish ownership after an idea is proved out and becomes a successful product. When handling ideas, great care should be exercised to reduce the risk of involvement in costly litigation. Before any idea is accepted, it should be positioned patentwise.

Patentability may be essential to the commercial success of the venture. If so, the proper coverage to be obtained must be determined. The idea may touch on patents which have been issued. It will be necessary to attempt to evaluate patents pending that might cause trouble—this is usually extremely difficult.

Licenses may be involved in readying the product for market. Ideas and inventions are likely to relate closely to work being done by other corporations along similar lines. Corporations owning patents touching the idea under consideration will expect to receive compensation for the use of features covered by their own patents. Identification of the controlling patents and the nature of licenses granted serve as a guide in evaluating the potential merit of an idea.

There are a number of aspects to consider in working with ideas and inventions from outsiders. Individuals have a property right in their ideas and inventions, even though these ideas and inventions are not patented. Outside ideas can represent a very real liability when the individual has not assigned patent rights to the corporation. When an idea or invention is offered to a corporation there is usually an implied confidential relationship. A corporation, rejecting an idea for one reason or another, may be subject to liability if a product relating to that idea is produced at a later date.

Generally, it will be undesirable to reveal all the reasons against acceptance of a particular idea. The firm's research group may already be working on the idea, for example. However, it is difficult to prove to a jury that a rejected idea paralleled work already in research when a suit has been instituted for alleged fraudulent action.

Development costs may be too great. The value of the idea itself may represent only a fraction of the investment necessary to reduce the idea to practice. This is a difficult point to get across to the inventor.

Ideas may be valueless because they infringe upon existing patents, or they may not be patentable at all, having been anticipated. These are a few of the problems that may be encountered.

As a general rule, all ideas originating from individuals who have not signed patent agreements should be passed on to the legal department. In many companies, it is standard procedure to advise inventors that ideas will not be considered un-

less a patent has been applied for or the inventor is willing to sign a waiver allowing the corporation to study the idea and establish its value. This policy protects both the inventor and the corporation. In a recent article,* Hastings has given a complete discussion of the advantages and disadvantages of working with outside inventors. Once these are understood, formal working agreements can be established with outside inventors and their patents or ideas accepted for consideration.

Preliminary Technical-Economic Study

A technical-economic evaluation seems to call for accomplishing the impossible in the shortest possible time. Tacit acceptance of this condition puts one in the right frame of mind for the preliminary survey of the chances for success of a product. Naturally, such an evaluation calls for a lot of guessing. In retrospect, however, this guessing may not be too bad because it will incorporate every possible known fact bearing on the situation. Beyond this, the guessing will be oriented in such a way that the aggregate guesses will serve as checks and balances.

An understanding of the nature of a technical-economic evaluation must precede any preliminary attempt. Without this background it is difficult to place variables in their proper perspective. Objective of the preliminary survey is to examine an idea in the light of available knowledge so that time and money will not be spent on developing a product that is not a relatively good risk. Product ideas could be better defined later, and a better job could be done after further definition and development. While true, the fact remains that further definition and development would cost more time and money. The purpose of the preliminary survey is to substitute brainpower, if possible, for time and money. To the degree that commercially feasible ideas can be brought into focus, product programs can be directed in the most productive channels.

Somewhat oversimplified, a technical-economic evaluation of a new product idea has as its object the answering of two questions:

1. Can it be made?
2. Can it be sold at a profit?

As soon as these questions are answered, the evaluation has served its purpose. The first question relates directly to the technical feasibility of the idea and takes into consideration research, development, production, marketing, installation, and servicing. The second question is an analysis of the economic feasibility of the investment. Answering these two major questions leads to other questions that must be asked.

*George S. Hastings—"Outside Inventors," MACHINE DESIGN, August 22, 1957, Pages 90-97.

Relating to the technical feasibility:

1. Can a prototype be developed?
2. Is adequate technology available?
3. Can gaps in know-how be filled?
4. Could the product be mass produced?
5. What would it cost?
6. How long would it take to get into production?

Analysis of economic feasibility raises the questions:

1. Who are the customers?
2. How many are there?
3. What do they want?
4. How much would they pay?
5. What would it cost to develop this market?
6. How long would it take?

Two other aspects must be given careful attention at this point. The first of these has to do with long-range trends—important determinants in the success of product programs. Trends are often discounted too heavily by projection of the present status into the future. Frequently the reaction is, "Since competition never permits such an idealistic model to unfold into reality, why try to build a dream castle in the first place?"

Competitors have their long-range plans. Consumer trends are apparent. Technological trends can be detected. Certain natural resources are declining in quality and quantities, others are becoming more abundant. Legislative trends represent significant factors. All of these affect product programs in varying degrees.

This leads directly to the second factor. In considering a new product, antitrust aspects should be considered. Falling into both general and special categories, laws have been enacted both at the national and local levels that effectively establish certain limits on new-product offerings. These laws are binding on both big and small business.

Two basic statutes are the Sherman Act and the Federal Trade Commission Act. The Sherman Act provides, in part:

> Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is hereby declared to be illegal.
>
> Every person who shall monopolize, or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of misdemeanor.

The Federal Trade Commission Act, the second basic statute to consider, reads, in part:

> Unfair methods of competition in commerce and unfair or deceptive acts or practices in commerce, are hereby declared unlawful.

Contemplated new-product offerings should be reviewed to analyze their possible effect as a restraint to free competition in business and commercial transactions. Tendencies to avoid are

those that may restrict production, raise prices or otherwise control the market. The objectives of the antitrust laws are clear, but they are difficult to apply. Contemplated action, in doubtful cases, should be reviewed with legal counsel competent in the antitrust area. Otherwise, even a successful new product can turn out to be a liability.

The over-all objective of the technical-economic survey is to establish the relative commercial feasibility of the idea at the earliest possible moment, with a minimum expenditure of development time and money.

Study of the Literature

Valuable resource material for product analysis has been developed by trade association groups, professional societies, government agencies and individual corporations. In addition, there are the continuing contributions of those working in areas of specialization. Do not make the assumption that, because material is available without charge, it is without value. Some of the most authoritative technological and industrial writing is available at little or no cost because its preparation and publication costs are absorbed by a corporation or other group as a service gesture. Only the best material merits such sponsorship. As a result, quality may be inversely related to price; the most costly may be of the most questionable value.

Literature reviews should be on a continuing basis. As specific product ideas come under consideration, the study should be intensified. The development of the transistor changed a lot of thinking in the electronics industry. Those who kept up with the literature could have anticipated this development sufficiently in advance to incorporate it in long-range planning. Technological developments, economic trends, and news of the business community have a direct bearing on products decisions. All of these are part of the background for analysis and decision making.

One very important value of the literature study lies in the fact that it affords the best opportunity of gathering background data without tipping one's hand to a competitor. Almost any other approach to data gathering introduces the risk of revealing specific interests.

Beyond this, when close contact with the literature is not maintained, decisions are usually made in an informational vacuum. The skilled analyst is one who has learned how to keep in touch with significant literature that bears directly upon his operations. By keeping abreast of developments, he can separate specious statements from penetrating analysis. If the analyst is willing to take time to personally investigate and check some of the information culled from literature, he can operate with reasonable assurance that he has a sound basis for decision.

Failure to review literature on a continuing basis results either in the loss of valuable data or its development in a more costly manner. In either event, the process of screening and appraising product ideas is seriously impaired.

Appraisal and Evaluation

Now that the facts have been corralled, they must be used as a basis for decision and action. Essentially, this is a process of adding up the plus and minus signs. However, this statement represents an oversimplification of what is involved, if it is left without examination of a number of extremely important considerations.

First, it is important to check all essential information for accuracy and to assemble it together for effective presentation. Management time is too valuable to waste sifting through a morass of accumulated detail. There is no greater deterrent to executive action than the absence of adequate, streamlined data to base decisions and action upon.

Second, it is important to bring together everyone who should have a part in a new-product decision. In selecting these individuals, it must be recognized that both functional facts and social-political relationships may be determining factors in deciding whether an idea is selected or rejected. To be realistic, this can not be overlooked. It is at this point that forces should be brought to play by facts, analysis and logical reasoning. Decisions should be reached in an atmosphere which reveals the true circumstances underlying the development of the final decisions. Personal bias in decision making can be minimized if the individuals are required to expose their reasoning to the others.

Third, the evaluation process itself deals exclusively in a selection of alternate courses of action based on relative values. Formulas are not workable. There are no established criteria that are universally applicable. Even the decision to take no action introduces an element of abandoned exporatory costs and loss of potential profits.

Decision and Action

This step terminates consideration of many of the ideas which have been screened. At the same time, it opens the door to the expenditure of substantial sums of money for research and commercial development of those ideas that are accepted. For both of these reasons, it is an important step. Losses will result both if unsound ideas are judged

acceptable or if good ideas are rejected.

The process of screening and appraising ideas is perhaps the most important single step in the process of developing new products. Too often, attention is directed to the analysis in subsequent steps. This misdirected attention is analogous to looking down a gun bore to see what makes the projectile come out. Aside from the personal risk attached, you don't learn anything. The breach of a gun, not the end of the bore, is the part to examine if you want to study the gun's mechanics. Top management's primary function lies in the planning area. Nontheless, many top-management men become embroiled in operating detail. This misspent effort usually comes from substituting mechanical effort for more difficult but less readily noticeable mental effort.

Decision and action call for an appraisal of the future. The commercial life of new products lies in the future, not the present. Decisions alone can not be expected to guarantee successful end products. Even an established product's future can not be projected with any accuracy. The intangible nature of ideas makes predicting their course even more difficult. Decision and action must be based on bringing together significant facts and competent personalities. It is necessary that everyone is included in the final screening process, including those directly responsible and those whose opinions are influential. All pertinent facts and opinions must be reflected in the decisions reached. This is the only basis for effective action and harmony in long-range product planning.

BIBLIOGRAPHY

This article is the fourth in a co-ordinated group by Dr. Marvin on new-product development. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

"Planning Product Strategy" .....June 13, 1957
"Developing Ideas for New-Product Programs" ....July 11, 1957
"Profitable Fields for New-Product Development" ..August 8, 1957

They Say . . .

"Super-pressure research—which a couple of years ago resulted in a process for making diamonds—and more recently, that still more glamorous and valuable substance, borazon, is another prime example of value added by science and technology. It's no secret that diamond, whether made by nature or in the laboratory, was transformed from carbon, which in comparison to diamond has almost no value.

"Even a 49-cent jar of peanut butter has a healthy content of carbon. Since scientists, like everybody else, can't resist having some fun with their work now and then, one of ours recently tried to make diamonds out of peanut butter. He succeeded, but I hasten to add that it's not quite as simple as it sounds. Also, peanut butter, in comparison with some other carbonaceous compounds, just isn't a very good material to start with—at least not good enough to justify further investigation into the relative merits of creamy style versus crunchy style."—DR. GUY SUITS, *vice president and director of research, General Electric Co., Schenectady, N.Y.*

"By virtue of training, position, and comprehension, the engineer occupies a unique niche in the social order. His profession is still new; he has not had time to digest its importance, nor does he fully understand the possible scope of his influence. The times are fraught with much tension, and decisions are sometimes dangerous because our morals have not evolved at the same pace as our technology. The engineer has acquired new responsibility along with power. This is a duty of the highest moral sort."—SHERWOOD B. MENKES, *City College, New York.*

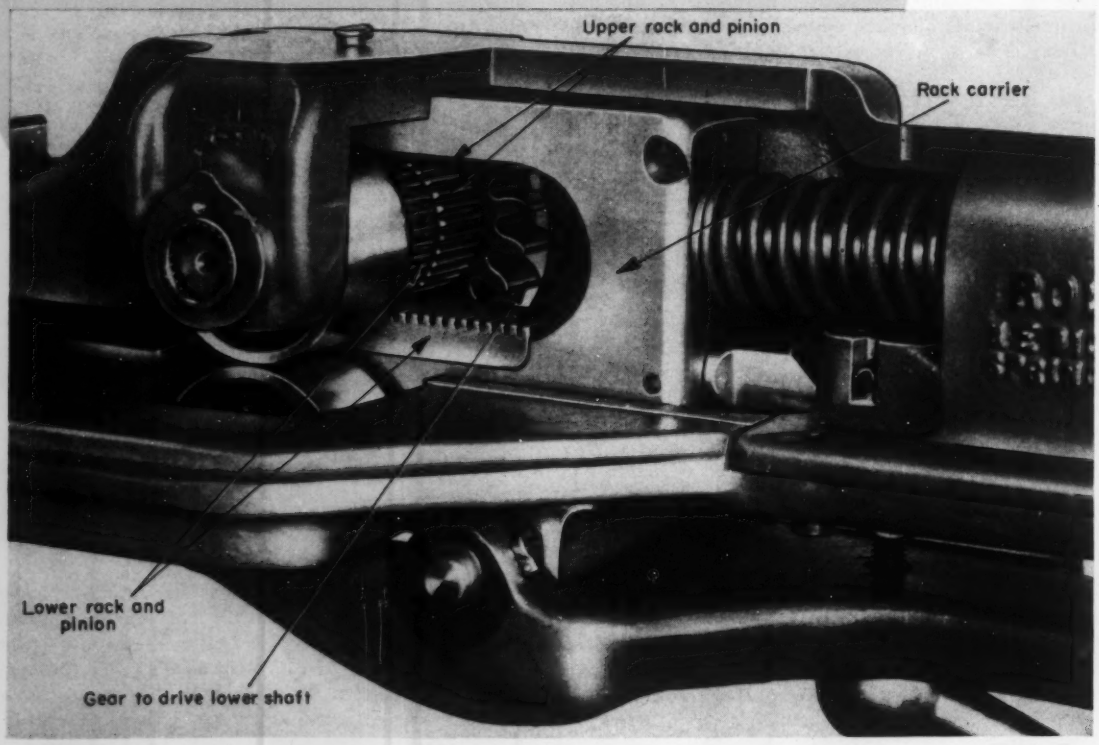
"Most important of all, it was emphasized that the basic research now being carried out in Russia is not being hindered or confused with applied, industrial, or military research. The Russian leaders apparently feel that their economy is strong enough to afford both, and they feel a dedication to the importance, the criticalness, and promise for the future which only basic research can bring."—JOHN H. HELLER, M.D., *executive director, New England Institute for Medical Research, Ridgefield, Conn.*

"If a young man goes at his work as a means of making money only, I am not interested in him. However, I am interested if he seems to do his work for the work's sake, for the satisfaction he gets out of doing it.

"If I were able to bequeath one virtue to every young man, I would give him the spirit of divine discontent, for without it the world would stand still. The man hard to satisfy moves forward. The man satisfied with what he has done moves backward."—CHARLES PROTEUS STEINMETZ.

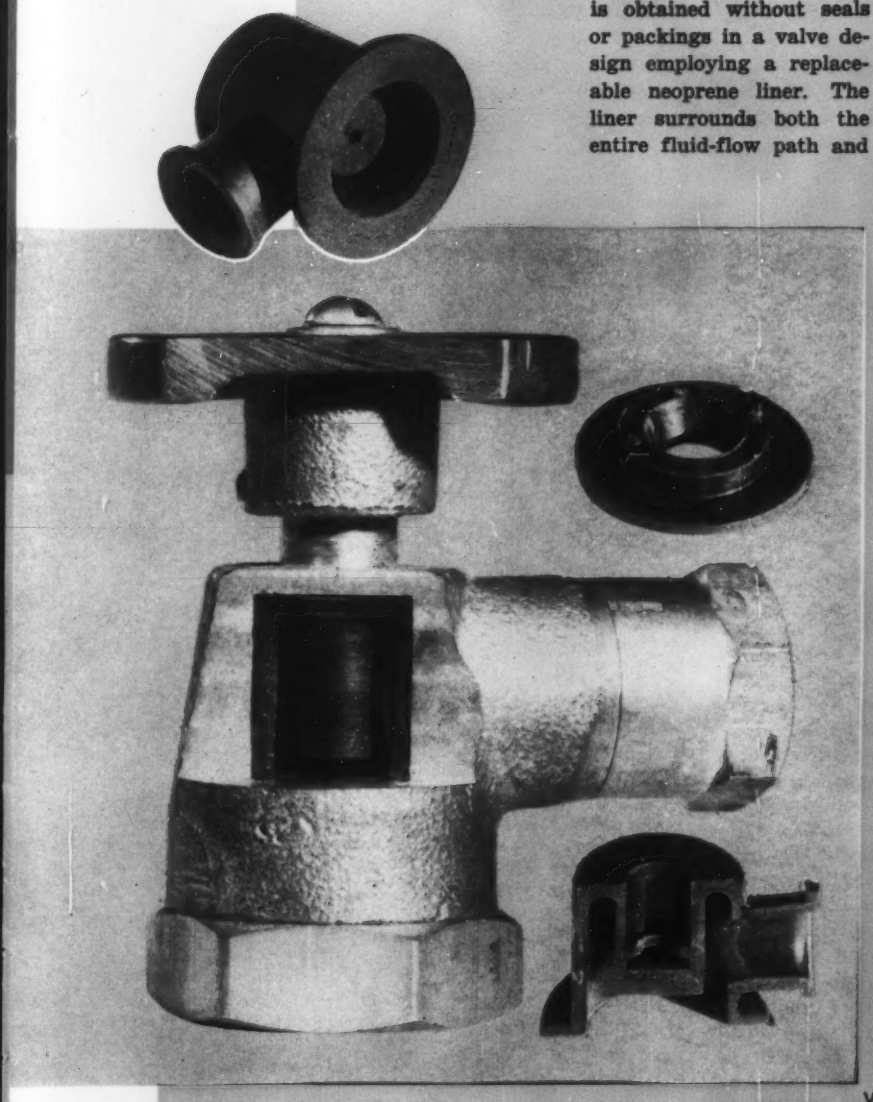
scanning the field for *ideas*

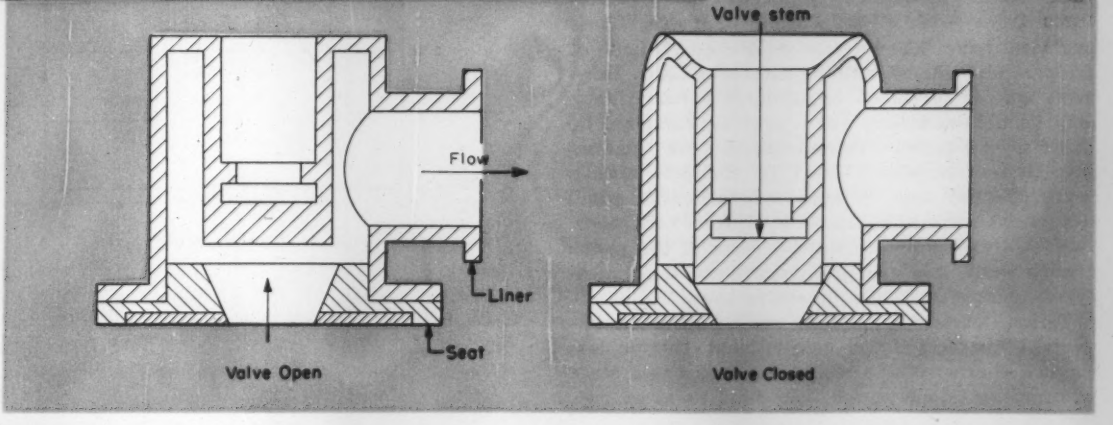
Dual rack-and-pinion assembly for linear-to-rotary conversion of motion provides one-way output rotation regardless of direction of input motion. In a press feed designed by Dickerman Manufacturing Co., two pinions with overrunning clutches are mounted on a common shaft. Each pinion engages a movable input rack. One rack engages its pinion on top, the other on the bottom. As the rack carrier moves forward, one rack-and-pinion assembly rotates the shaft while the other pinion freewheels. On the return stroke of the rack carrier, the opposite rack-and-pinion assembly drives the shaft to maintain the same direction of output rotation.

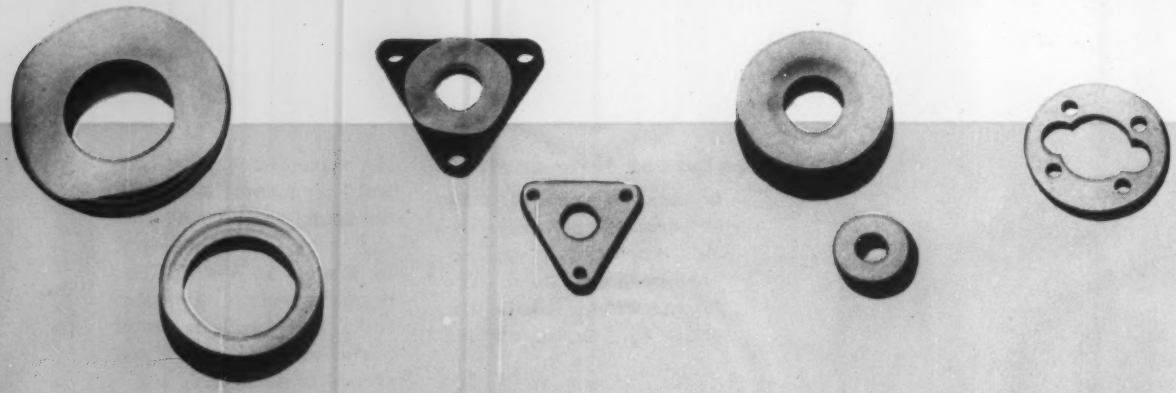


Leakproof flow control is obtained without seals or packings in a valve design employing a replaceable neoprene liner. The liner surrounds both the entire fluid-flow path and the valve stem. Flow control is accomplished by distorting the liner against the valve seat. Developed by Walter L. Veatch Inc., the construction eliminates leaks and protects metal parts against wear and corrosion damage.

The snap-in liner consists of two parts: the liner itself and a separate seat. The liner fits into the valve body, sealing all metal surfaces from the fluid, and the seat fits into one end of the liner. The valve stem snaps into a cup in the liner. With the valve seat in place, fluid-flow shut off is accomplished by screwing the valve stem down, distorting the liner until it contacts the seat. The liner and seat make straight-line contact, without rotary motion, eliminating seat wear. Due to the resilience of the liner and seat, abrasive fluids may be handled without damage to the unit.







DESIGNING WITH TEFLON

Part 1—How Processing Affects Properties

TEFLON plastics have a unique combination of electrical, chemical, temperature and friction-resisting properties. These fluorocarbon plastics have been established as outstanding materials for electrical insulation at high temperatures and at high frequencies; as gasketing and packing in the chemical processing industries; as bearings; and in many other applications.

Design and engineering data presented in this series of articles on Teflon tetrafluoroethylene resins are intended to assist the design engineer in determining where and how these resins may best be used.

General Characteristics: Fabricated shapes of Teflon plastics are tough, flexible in thin sections, and fairly rigid in massive pieces. They maintain their useful mechanical properties at temperatures from −450 F to +500 F or more. Their surfaces have an extremely low coefficient of friction, and almost nothing sticks to them. However, special forms of tetrafluoroethylene plastic may be obtained that will accept conventional industrial adhesives. Tetrafluoroethylene plastics are almost completely inert to chemical attack, being affected only by such substances as alkali metals and some halogens under special conditions. The low-loss electrical characteristics of the resins remain essentially constant, regardless of frequency, over a wide range of temperature.

Teflon tetrafluoroethylene resins differ in important respects from conventional thermoplastic and thermosetting resins. In their usual state at ordinary temperatures, they tend to be opaque,

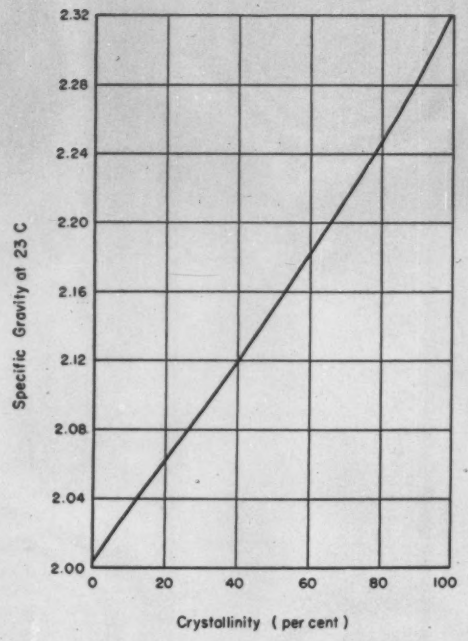


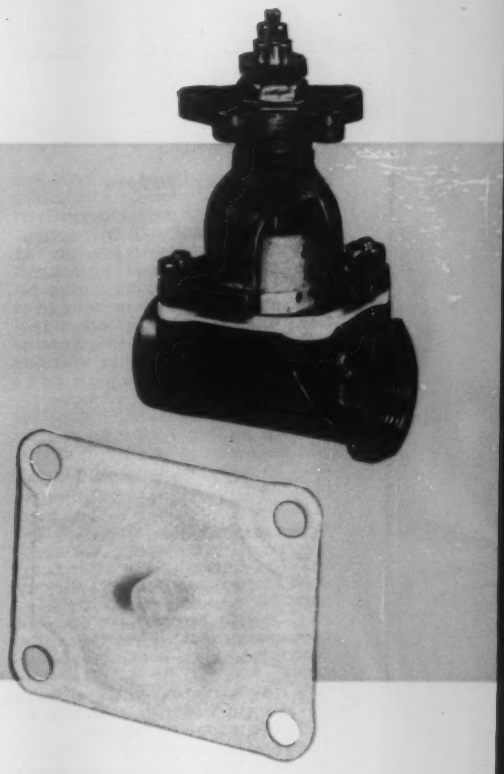
Fig. 1—Crystallinity of tetrafluoroethylene plastic versus specific gravity.

Tetrafluoroethylene plastics, such as Du Pont's "Teflon," are unique engineering materials. Their unusual properties make them well worthwhile for a designer to consider for difficult components.

Teflon plastics are almost completely inert, have excellent low and high-temperature resistance, retain good electrical insulation characteristics over a wide temperature range, and have "slippery" surfaces which make them suitable for bearings and "nonstick" applications.

In this series of four articles, the properties and uses of Teflon tetrafluoroethylene plastics are comprehensively covered. Methods of designing with Teflon are also reviewed as a guide to efficient design of parts.

This series is based upon design and engineering information prepared by the Polychemicals Dept. of E. I. du Pont de Nemours & Co. Inc. Many Du Pont people are responsible for the basic engineering data in this series. Special thanks are due, however, to Mr. Frank M. Chapman for his help and illuminating comments.



crystalline, and malleable. On being heated above 620 F, they become translucent, amorphous, and relatively intractable, fracturing if severely deformed. They return to the opaque, crystalline, malleable state on being cooled below 620 F.

Teflon can be aggregated into dense coherent shapes at temperatures below 620 F by various "cold-forming" techniques. Cold-formed products can be strengthened by sintering, which involves heating at temperatures above 620 F, generally 700 to 720 F, until the resin particles coalesce and then cooling below 620 F. Sintered products may then be further shaped by various postforming techniques, most readily at temperatures approaching but below the 620 F transition temperature. Cold forming, sintering, and postforming are the techniques most commonly employed in the processing of tetrafluoroethylene into useful articles.

Typical compositions are outlined in Table 1. Major areas of applications are reviewed in Table 2.

Table 1—Teflon Compositions

Type	Usual Method of Processing	Description	Major Uses
Teflon 1	Compression molding, ram or screw extrusion	General - purpose powder for molding and extrusion	Gaskets, packing seals, rings, electronic components bearings, sheet, rod, heavy wall tubing
Teflon 5	Compression molding, ram or screw extrusion	Special - purpose powder for molding cylindrical shapes for the production of skived tape	Tape and molded shapes for chemical, electrical, mechanical, and nonadhesive applications
Teflon 6	Lead-press type extrusion	Special - purpose powder for compounding and use in extrusion	Thin - walled tubular goods, wire coating, and electrical tape
Teflon 30	Dip coating	Aqueous dispersion	Impregnation of glass cloth and asbestos

▶ Effect of Processing*

Various physical properties can be obtained in Teflon by variations in processing techniques. These resins are versatile and can, within limits, be "tailored" by the fabricator to provide the most desirable physical properties in fabricated parts.

Some properties are relatively insensitive to changes in fabrication technique, while others are to a large extent under control of the fabricator. Good thermal and chemical resistance, nonadhesiveness, low power factor, and low dielectric constant are inherent in the chemical structure of the tetrafluoroethylene molecule and are relatively independent of the fabrication method. Other properties, such as stiffness, flex life, permeability and tensile properties, can be altered by the fabricator. Most of the information covered here was developed during work with Teflon 1 granular molding powder, and to a lesser extent with Teflon 6 extrusion powder.

*Adapted from "Effects of Fabrication on the Properties of 'Teflon' Resins" by P. E. Thomas, J. F. Lontz, C. A. Sperati, and J. L. McPherson, *SPE Journal*, plus additional material supplied by Mr. Frank M. Chapman.

Table 2—Applications of Teflon Plastics

Electrical Applications

Properties of tetrafluoroethylene plastics make them particularly suitable for insulation at high frequencies and high temperatures. Thin, flexible Teflon insulation is used in many applications where the use of other materials is impossible. Because of their flexibility in thin sections and toughness, components molded of Teflon frequently simplify installation. Tape is easy to handle, conforms well to odd shapes, and is readily adaptable to automatic wrapping operations.

Wire and Cable

Tetrafluoroethylene resins are used for insulation of motors, generators, and transformers of all types in aircraft, automotive, communications, electronics, locomotive, and machine equipment.

Wire insulated with enamels made from Teflon is used in fractional-horsepower motors, electronic transformers, thermocouples, and control equipment (such as aircraft controls). Primary advantages offered by wire insulated with these resins are their high service temperature and low power loss.

Wire with insulation of medium thicknesses is used in electronic applications (as hook-up wire), distribution and power transformers, and aircraft, integral, and traction motors; and under corrosive conditions (as in chemical plants).

Thick-walled insulation of Teflon tetrafluoroethylene resins is used in coaxial cables for radar and television, and on wire designed for use under conditions of high voltages and high temperatures. The excellent dielectric characteristics available over the full range of frequency and temperature by the use of these resins make them outstanding candidates for insulating applications of this kind.

Motors and Generators

Motors and Generators

Insulation of tetrafluoroethylene resins gives outstanding performance in many sizes and types of electric motors and generators, especially when service temperatures are too high for other dielectrics, when ruggedness and dependability are paramount, or when motors must operate in corrosive atmospheres. Tape made from Teflon is particularly suitable for motors and generators. Uses include conductor insulation for armature or field, coil wrappers, slot liners, taping of coils, lead insulation, and coil separators within slots.

In addition to these uses of tetrafluoroethylene resins in tape-wrapped constructions, fine wire coated with Teflon enamels is used in synchronous and fractional horsepower motors, and wire insulated by extrusion (as well as by tape-wrapping) is used in integral and traction motors.

A motor will tend to run cooler with insulation made from tetrafluoroethylene resins. Heat transfer is better because Teflon is a compact, solid structure.

Transformers and Coils

With development of new fabricating techniques for tetrafluoroethylene resins, it is now possible to design transformers capable of operating at hot-spot temperatures as high as 550 F.

Teflon tetrafluoroethylene resins are used in transformers as conductor, layer, and ground insulation, and for coil separators. For electronic transformers, wire is coated with Teflon enamel. For distribution transformers, wire is insulated by extrusion, or taped constructions are used. Such constructions can be fused after assembly, which excludes air and provides a compact coil unit.

For power transformers, these resins are used as conductor and layer insulation in the forms of tape and laminates made from glass cloth coated with tetrafluoroethylene resins. Laminates provide high resistance to cut-through and abrasion.

Capacitors

Tetrafluoroethylene resins are giving outstanding service in electronic and line capacitors where ambient temperatures are high and minimum power loss is essential. It is used as the dielectric in wrapped capacitors.

Two layers of cast tape are used between conductor plates for electronic capacitors, while two layers of shaved or extruded tape are used in line types. Much higher dielectric strength can be achieved with two layers than by a thicker single layer.

Power Distribution Units

Because of their resistance to heat, weather and moisture, and their low loss factor, these resins are particularly suitable for use in power distribution equipment. These uses include insulation for wire and cable, and insulation for motors, generators, and transformers. Laminates of glass fabric coated with Teflon resins are also important in components for power distribution equipment.

Electronics Equipment

Tetrafluoroethylene resins are used in electronics equipment as molded components, tape, and extruded insulation. Excellent dielectric properties even at ultra-high frequencies, and moisture resistance, are particularly important in the electronics field.

Components molded of tetrafluoroethylene resins include tube sockets, inserts for coaxial connectors, coaxial spacers, bases for subassemblies, terminals, and small stand-off insulators. A variety of types and sizes of high-temperature hook-up wires for electronic appliances are insulated with these resins for a combination of properties not otherwise obtainable in a thin, flexible jacket. Such insulation is either extruded or tape-wrapped.

Other uses of tape made from Teflon tetrafluoroethylene resins include layer insulation and coil separators. Thin film cast from Teflon dispersion is used for electronic capacitors, and for wrapping small components. Laminates of glass fabric coated with tetrafluoroethylene resins are used for terminal boards, bases for printed circuits, and subassembly mounting boards.

Chemical Applications

Fabricated parts of tetrafluoroethylene resins have been employed in the most corrosive service encountered in the chemical industry. In many instances, these resins have been found to be the only material that would give satisfactory performance. Teflon plastics frequently improve quality of the product being processed because they will not contaminate it.

Gaskets

All types of gaskets are made of tetrafluoroethylene plastics. For many uses, solid gaskets give satisfactory service. Some other applications are better served by one of a variety of jacketed and spiral-wound gaskets.

Envelope gaskets, in which a filler is enclosed in a shield fabricated of Teflon, are used where bolting pressures are limited, as is the case with comparatively fragile pipe made from ceramics, glass or carbon, and glass-lined equipment.

Spirally wound gaskets and gaskets made from asbestos and glass cloth impregnated with these resins are used in high-pressure installations—pipe joints, valve bodies, reaction kettles, pump bodies, packaging closures, and containers for compressed gases.

Gaskets have been used successfully in contact with bromine, chlorine, sulfur dioxide, concentrated sulfuric acid, aqua regia,

organic solvents of all types, and many other corrosive materials.

Packings

Packings made from Teflon resins are supplied in many forms. Solid rings having a rectangular cross-section are completely impervious to gases and liquids, and have simplicity of design. They are used singly or in series. Tapered wedge rings show an advantage over solid rectangular rings in some cases, because they can be sealed with lower gland forces.

A variety of special shapes is also made of tetrafluoroethylene plastics. The V-ring and cup-and-cone ring, for example, are designed to provide a seal with minimum gland pressure between parts having comparatively little relative motion.

Braided packings are made of twisted ribbons fabricated of Telflon, usually in combination with asbestos yarn. These packings are suitable for valves and low-speed shafts, and are convenient for ready installation in stuffing boxes of various sizes.

Extruded and molded plastic packings consisting of tetrafluoroethylene resins and a binder are easily shaped in the stuffing box, and will seal at low gland pressure.

Packings made of asbestos braid impregnated with tetrafluoroethylene resins provide excellent chemical resistance, yet maintain the strength and resiliency of asbestos fibers.

As in the case of gaskets, packings made of tetrafluoroethylene resins have given excellent service in many types of chemical equipment — pumps, valves, agitators, etc.—handling the most corrosive materials.

Valve Components

Gaskets and packing for valves were among the earliest applications of Teflon. When made of tetrafluoroethylene resins, these parts normally outlast the valve itself, permit miniaturization of packing glands, and require less torque to open and close the valve.

These plastics in valve seats and disks frequently permit interchangeability of valve parts, simplification of design, and improvement in operating characteristics. Resiliency of this material is an important factor in valve seats, providing tight, leakproof seating.

Tetrafluoroethylene plastics are used to fabricate a liner for plug cock valves. In this application, the liner prevents freezing of the plug in the body and eliminates the need for intricate and costly design usually involved in lubricated valves.

Teflon resins have also proved successful diaphragms for valves of the Saunders type. Some diaphragms for pressure-controlled valves are made from either these resins alone or glass cloth impregnated with tetrafluoroethylene resins.

Pipe and Tubing

Several types of pipe and tubing are made of tetrafluoroethylene plastics. These include:

1. Tubing made from laminate of glass impregnated with tetrafluoroethylene resins—both with and without a solid lining fabricated of Teflon.
2. Unsupported thin-wall tubing made from Teflon. Thin-wall tubing with an overbraid of wire, cloth, or rubber.
3. Pipe (in standard sizes) made of both Teflon and compounded Teflon.
4. Metal pipe lined with thin-wall tubing of Teflon.

Mechanical Components

A large field of application for fabricated tetrafluoroethylene is in mechanical parts. Gaskets and packings made of these resins are used satisfactorily in countless pump applications handling corrosive chemicals. In mechanical seals, these parts fabricated from Teflon offer an excellent combination of chemical resistance and mechanical properties which results in reduced maintenance by eliminating periodic gland repacking.

Of particular importance is the low coefficient of friction exhibited by parts fabricated of Teflon. Form-stability under load is enhanced by the proper filler, while other properties remain substantially unchanged.

Bearings for pumps are excellent examples of good use of Teflon's properties. In this use, chemical inertness plus low frictional properties provide a bearing with service characteristics that cannot be matched by bearings made of other materials.

A bearing made of reinforced compositions of tetrafluoroethylene resin is used on the rolls of a textile spinning machine to eliminate lubricants and resulting contamination by oil. This end bearing runs on a shaft of hardened steel. The shaft turns at about 100 to 200 rpm, and the bearing is subjected to loads of about 175 psi. This filled composition operates satisfactorily without lubricants at these loads and speeds. Reinforced compositions of tetrafluoroethylene resins are also used for piston rings in nonlubricated compressors where oil-free air is required.

Where difficult bearing applications are encountered, and particularly where corrosion or high temperatures present a problem, or where normal lubricants cannot be used, reinforced compositions of Teflon plastics may provide the answer.

Nonadhesive Applications

The nonadhesive property of parts fabricated from Teflon is utilized in a variety of operations in which sticky materials are handled.

These resins are applied to surfaces for nonadhesive purposes as a solid film or extruded or molded shape which can be attached to the equipment by mechanical means; as a finish, applied directly to the substrate by use of a primer coat and multiple spraying and fusing operations; or as a glass cloth impregnate.

In general, solid forms fabricated from tetrafluoroethylene are used when the surface is subjected to hard mechanical usage and may require periodic resurfacing; or where flexibility is needed; or where, because of size or other considerations, it is not feasible to apply a finish.

A finish (made from Teflon dispersion) is used where a thin film (not exceeding 4 mils) is desired over a metal substrate.

Glass cloth impregnated with Teflon dispersion is used where a combination of flexibility with strength and dimensional stability is needed in a thin film.

On bread-sheeting rolls a coating provided by tetrafluoroethylene resin eliminates accurately ground scrapers otherwise needed to strip the sticky dough from the sheeting rolls. It reduces or eliminates dusting flour used to reduce sticking and makes it possible to produce bread of improved quality because a thinner sheet is rolled.

Teflon resins on the surface of heat-sealer plates of wrapping machines eliminate sticking of packaging materials to sealer plates and prevent build-up of foreign matter on the plates. Other uses in packaging machinery include guides, dead plates, and hoppers of packaging machines to reduce cleaning and improve operating efficiency.

These resins are also used to provide nonadhesive surfaces in a variety of other applications in food-processing equipment, especially in machinery used in preparation and handling of candy; in the rubber and plastics industries to prevent sticking to molds and platens; and in industries in which glue is handled extensively.

Basic Factors: Teflon resins are fabricated by a number of techniques including ram extrusion, screw extrusion, preforming followed by pressure or free-sintering, and extrusion with an extrusion aid. These techniques, while different, have three basic steps in common: (1) cold pressing, (2) sintering, and (3) cooling. The three steps refer to operations that involve, respectively: densifying molding powder by pressing; bonding adjacent surfaces of particles by heating; and controlling crystalline content of the article by cooling. The way the fabrication steps are carried out affects three basic factors that determine certain final properties of Teflon tetrafluoroethylene resins. These three parameters are crystallinity, molecular weight, and void content.

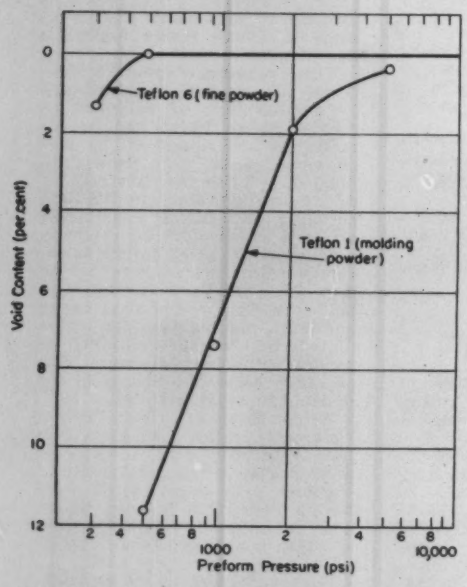


Fig. 2—Effect of preform pressure on void content of Teflon 1 moldings sintered 3 hr at 716 F.

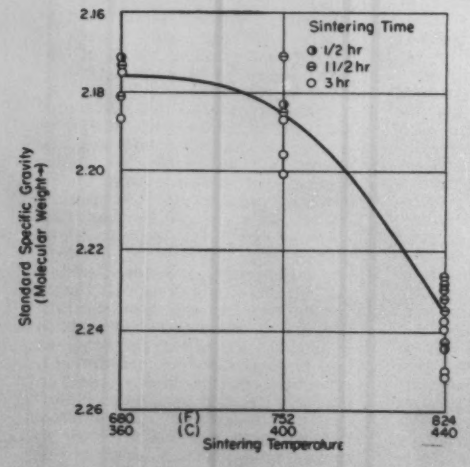


Fig. 3—Effect of sintering time and temperature on molecular weight of Teflon 1.

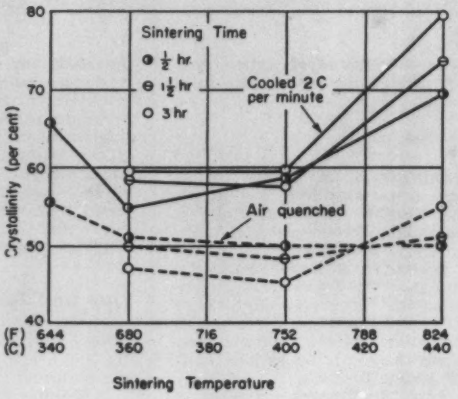


Fig. 4—How sintering time, temperature and cooling rate affect crystallinity of Teflon 1 moldings.

Table 3—Effect of Sintering Conditions on Void Content*

Sintering Time (hr)	Sintering Temp. (F)	Preform Pressure, 2000 psi Void Content (%)	Preform Pressure, 5000 psi Void Content (%)
½	680	2.7	0.5
	752	4.4	1.4
	824	6.0	0.4
1½	680	1.4	0.8
	752	2.4	1.2
	824	6.3	2.3
3	680	2.2	0.6
	752	1.4	0.4
	824	5.8	1.0

*4 x 5 x 1/16-in. molded sheets of Teflon 1. Lower values would be expected for thicker moldings and for moldings sintered in a mold.

Methods of Measuring: Before the importance of the three basic factors can be discussed, methods used to measure them must be outlined.

Crystallinity is determined by measuring the absorption of amorphous infrared band at 12.85 microns using thin polymer sections.

To determine the void content of a molding, its specific gravity and per cent crystallinity are measured. From the measured crystallinity and Fig. 1, the specific gravity, if no voids were present, can be determined. The void content is then defined by

$$V = \frac{S_c - S_m}{S_c} \times 100$$

where V = void content, per cent; S_c = calculated specific gravity (Fig. 1); and S_m = measured specific gravity.

A convenient method of measuring density, which is faster than standard laboratory tech-

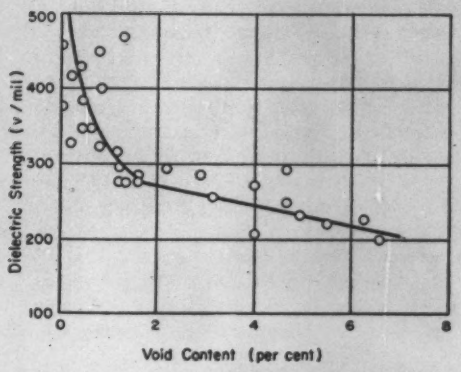


Fig. 5—Effect of void content on dielectric strength of 0.060-in. thick Teflon 1 (ASTM D149-49T, short-time test, Primol D test oil).

Table 4a—Effect of Cooling Rate on Crystallinity

Cooling Rate (deg C/min)	Teflon 1* Crystallinity (per cent)	Teflon 6* Crystallinity (per cent)
Quenched in ice water	44	50
5	54	65
1	56	72
0.5	58	74
0.1	62	78

*1½ in. diam x ⅛-in. thick moldings, preformed at 5000 psi, sintered at 716 F (380 C) and 50 min, cooled to 572 F (300 C).

Table 4b—Effect of Annealing on Crystallinity*

Annealing Time (hr)	Crystallinity (per cent) for annealing temperatures of: Teflon 1 583 F / 306 C	599 F / 315 C	613 F / 323 C	Teflon 6 583 F / 306 C	599 F / 315 C	613 F / 323 C
Ice quenched, then annealed*						
0.5	47	49	50	54	57	60
5	50	53	56	57	61	67
20	52	55	60	60	65	72
Cooled 1 C/min, then annealed						
0.5	56	57	57	74	74	75
5	56	58	59	74	75	76
20	57	59	61	74	75	78

*Preformed and sintered as in Table 4a. Annealed in salt bath at stated temperature; quenched in ice water.

niques, is with a density gradient tube. Although details of the technique will not be described here, the basic method involves use of a tube filled with liquid of graded density. The Teflon part will float at a position indicating its density.

Role of Processing: The three steps most commonly involved in processing tetrafluoroethylene plastics will be examined to see why the resins behave as they do when processing conditions are changed.

First, what molding conditions influence void content? Voids caused by insufficient consolidation of particles during preforming may be carried over into the finished articles, Fig. 2. Densities below 2.10 indicate a high void content. Particle size, shape and porosity are important in determining void content. Fig. 2 shows that Teflon 6, which has very small primary particles (about 0.25-micron), requires a preforming pressure of 500 psi to produce void-free moldings. In the case of Teflon 1, a preforming pressure of 3000 psi is required to produce moldings with void contents less than 1 per cent. While void content is largely determined by particle characteristics and preforming conditions, sintering conditions are also important. Sintering at too high a temperature can increase void content. Table 3 summarizes information on the effect of both preform pressure and sintering conditions on void content.

Molecular weight after fabrication is largely fixed by the initial molecular weight of the polymer. However, if the sintering temperature is intentionally or inadvertently raised above 734 F (390 C) for an appreciable time, molecular weight changes may be noticed. Examples of changes in relative molecular weight (standard specific gravity) produced by various thermal treatments are shown in Fig. 3.

Final crystallinity of a molding depends mainly upon initial molecular weight of the polymer used

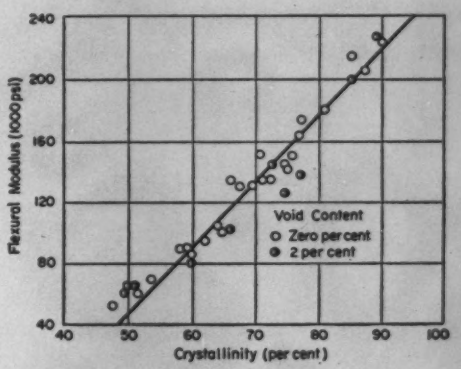


Fig. 6—Flexural modulus versus crystallinity (ASTM D790).

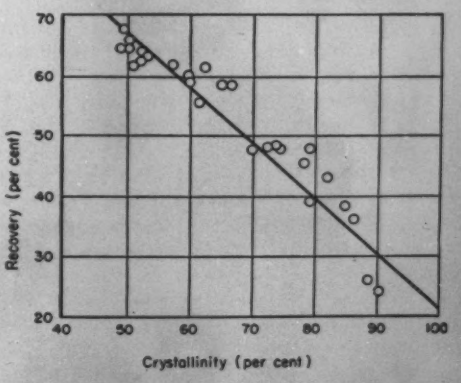


Fig. 7—Recovery versus crystallinity (ASTM D1147, 1/4-in. penetrator, 5-lb preload, 250-lb major load).

in fabrication, rate of cooling of the sample and, to a lesser extent, upon sintering conditions. The pronounced effect of molecular weight is shown in Table 4. Moldings of Teflon 1 (highest molecular weight resin) are 5 to 20 per cent less crystalline than moldings of Teflon 6 made under similar conditions. This table also shows that a fabricator can make marked changes in the crystallinity of moldings made from either resin by varying cooling rate or annealing conditions. As much as 20 to 30 per cent change in the level of crystallinity can be made by such changes in fabrication conditions.

Although final crystallinity is relatively unaffected by normal sintering conditions, indirect effects are noted for short-time, low-temperature sintering conditions, or on sintering at temperatures where degradation can occur, Fig. 4.

The wide variation in properties of tetrafluoroethylene plastics, depending on the level of crystallinity, raises the question of permanence of those properties. Fortunately, because of the extremely high molecular weight of these resins, appreciable changes in crystallinity do not take place except at very high temperatures. In Teflon 1, for instance, less than 10 per cent change in tensile strength and elongation occurs after aging 40 days at 545 F (285 C).

Influence on Properties: Certain properties depend on only one of the three factors—crystallinity, molecular weight, or void content. One such property is dielectric strength, Fig. 5, which at constant thickness increases with decreasing void content. Another is stiffness; a five-fold increase in stiffness can be obtained by increasing crystallinity from a level of 50 to 90 per cent. The quantitative relationship between stiffness and level of crystallinity is shown in Fig. 6.

On the other hand, recovery (as measured by one standard recovery test for gasket materials) decreases with increasing crystallinity, Fig. 7. Frequently, as in the case of stiffness and recovery, one property must be balanced against another with the proper choice depending on needs of the application.

Most properties are controlled by more than one of the fundamental parameters. The effect of both molecular weight and crystallinity on flex life can be shown on a property map, Fig. 8. The *Y* axis is per cent crystallinity and the *X* axis is relative molecular weight (standard specific gravity). The lines on Fig. 8 are flex life parameters. The figure shows that flex life increases roughly 100-fold with increasing molecular weight and also increases 100-fold with decreasing crystallinity.

To indicate relative effects of all three basic factors (molecular weight, crystallinity, void content) on a number of properties, Table 5 shows that many properties depend upon the level of crystallinity. As crystallinity increases from 45 to 90 per cent, the following changes can be noted: a 100-fold decrease in flex life; a 15-fold decrease in tensile impact strength; a 30-fold decrease in permeability to gases; and a 5-fold increase in stiffness.

Voids created through improper fabrication can also affect properties. In an extreme case (void content of 6 per cent), permeability to gases was increased 1000-fold, and impact strength, tensile strength, ultimate elongation, and dielectric strength were decreased 50 to 80 per cent.

Table 5 also shows that relatively few properties depend directly upon molecular weight. This fact does not mean that molecular weight is unimportant. Crystallization rates, and therefore final levels of crystallinity, depend on molecular weight. Molecular weight has its greatest effect on properties through this influence on crystallinity.

Controlling Properties Through Fabrication

Some simple recommendations showing how a fabricator can change seven important properties of tetrafluoroethylene plastics are shown in Table 6. For example, to obtain a maximum flex life, a molding should be quenched. On the other hand, to produce minimum permeability, a molding should be cooled slowly.

When high crystallinity is required to produce desired properties, sintering at temperatures below 734 F (390 C) and then cooling slowly across the 621 F (327 C) transition temperature is recommended. Rate of cooling required to achieve the desired crystallinity level can be determined from Table 4. Where higher stiffness and lower permeability are required than can be attained by this procedure, the sintering temperature can be raised above 734 F (390 C). Before choosing such conditions, careful consideration should be given to other molecular-weight-dependent properties

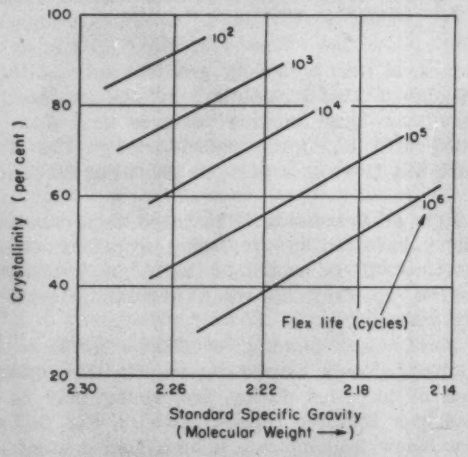


Fig. 8—How crystallinity and molecular weight affect flex life (nonstandard test, 45 cycles per minute, 180-degree bend).

which are adversely affected by these sintering temperatures. In any event, the decision as to molding conditions rests upon providing the proper balance of properties for each particular end use.

Typical properties for moldings made from Teflon 1 and Teflon 6 are given in Tables 7 and 8. These tables show the overall combination of properties at different levels of crystallinity. Tables 9 through 14 show the results of a detailed investigation of the effect of fabrication conditions on yield stress, elongation at yield point, ultimate strength, ultimate elongation, flexural modulus, and dielectric strength.

Practical Control of Properties: Theoretically, it is possible to control certain properties of Teflon plastics over quite a wide range by varying crystallinity. In practice, however, design of the part and cost of manufacture dictate levels of crystallinity which can be attained.

For instance, to produce parts of tetrafluoroethylene resins with low crystallinity, heat from sintering or annealing must be removed by rapid cooling. This is not feasible for thick sections (greater than ⅛-in.) since the plastic is a poor conductor of heat. When a thick section is cooled, low crystallinity material is produced near the cooled surface, but a higher crystallinity will prevail in the center of the piece.

Table 5—Effect of Molecular Weight, Crystallinity, and Void Content on Properties

Property	Maximum Change Due to Increase in Molecular Weight	Crystall.	Void Content
Flex fatigue life	+100-fold	—100-fold	—1000-fold
Compressive stress at 1% deformation	0	+50%	0
Compressibility	0	—50%	No data
Recovery	0	—70%	No data
Permeability to carbon dioxide	0	—30-fold	+1000-fold
Flexural modulus	0	+ 5-fold	—30%
Hardness, Durometer	0	+20%	No data
Rockwell	0	—20%	—30%
Scleroscope	0	—70%	—10%
Tensile impact strength	0	—15-fold	—80%
Dielectric strength	0	0	—70%
Proportional limit	0	+80%	—20%
Yield stress	0	+15%	—20%
Yield strain	0	—15-fold	0
Tensile strength	+25%	—50%	—50%
Ultimate strength	+50%	—70%	—50%
Ultimate elongation	—20%	+100%*	—80%

*Reaches a maximum at 85 per cent crystallinity; drops to 1/10 maximum about 85 per cent crystallinity.

Table 6—Molding Conditions Leading to Maximum Properties

Flexibility: Sinter below 734 F (390 C), quench.

Stiffness: Cool slowly.*

Flex Life: Maximum preform pressure, sinter below 734 F (390 C), quench.

Dielectric Strength: Maximum preform pressure, sinter below 734 F (390 C).

Resiliency: Sinter below 734 F (390 C), quench.

Impermeability: Maximum preform pressure, cool slowly.*

Tensile Strength: Maximum preform pressure, sinter below 734 F (390 C), quench.

*In the few cases requiring highest possible stiffness and impermeability, sintering temperatures of 734 to 824 F (390 to 440 C) can be used. Since other properties deteriorate above 734 F (390 C) balance of properties needed for each end use should be examined carefully.

High crystallinity can be produced throughout thick sections by slow cooling, which is time-consuming and increases cost of manufacturing.

In thin sections (less than ⅛-in.), both low and

Table 7—Typical Properties of Teflon 1 Moldings

Property (9)	ASTM Method	Low Crystallinity (1)	Moderate Crystallinity (13)
Specific gravity	D 792	2.13	2.15
Crystallinity (per cent)	Du Pont Infrared	50	56
Tensile strength (psi)	Du Pont (3)	2800	2300
Ultimate strength (psi)	Du Pont (3)	2800	2300
Ultimate elongation (per cent)	Du Pont (3)	250	180
Proportional limit (psi)	Du Pont (3)	1200	1300
Yield stress (psi)	Du Pont (3)	1800	2000
Yield strain (per cent)	Du Pont (3)	70	70
Flexural modulus (psi)	D 790	62,000	74,000
Compressibility (per cent)	D 1147(6)	22	16
Recovery (per cent)	D 1147	67	62
Deformation under load (per cent)	D 621 (5)	2.5	1.5
Flex life (cycles)	Du Pont	60,000	40,000
Permeability to carbon dioxide gas (2)	Du Pont	9	6
Tensile impact strength (ft-lb/sq in.)	Du Pont	200	100
Hardness, Scleroscope	Du Pont	67	60
Hardness, Rockwell J	D 785 modified	92	90
Flexural creep characteristics	Du Pont	20,000 (7) —0.09 (8)	30,000 —0.08
Dielectric strength (v/mil)	D 149 (4)	400	400

1. 1/16-in. sheets preformed at 5000 psi sintered 1½ hr at 680 F (360 C), quenched in air.
2. Grams/day (100 sq in.) atm-mil at 30 C.
3. Microtensile specimens 3/16 x 1/16 x ⅞-in. gage length. Crosshead speed 5 in./min.
4. One-inch rounded electrode. "Primol" D immersion oil. Short time method.
5. 73 F (23 C), 1000 psi stress, 24 hr.
6. ¼-in. penetrator, 5-lb preload, 250-lb major load, 73 F (23 C).
7. Apparent modulus, psi, at a stress level of 1000 psi after 100 hr.
8. Apparent modulus decay rate: (log apparent modulus, psi)/(log time, hr).
9. Properties which are not markedly affected by fabrication such as dielectric constant, power factor, volume resistivity, flammability, coefficient of friction, and chemical resistance are not included in this table.
10. 1/16 to ¼-in. moldings, preformed 5000 psi, placed in oven at 716 F (380 C) for 50 minutes, quenched in ice water.
11. Same preforming and sintering as Note 11. Cooled 2 F/min.
12. Carried through Note 12 cycle, then annealed for 35 days at 595 F (313 C).
13. Same preforming and sintering as in Note 1. Cooled in oven at 4 F per minute.

Table 8—Typical Properties of Teflon 6 Moldings

Property (9)	Low Crystallinity (10)	Moderately High Crystallinity (11)	Very High Crystallinity (12)
Specific gravity	2.15	2.22	2.25
Crystallinity (per cent)	50	72	82
Tensile strength (3) (psi)	4200	3100	2000
Ultimate strength (psi)	4200	3100	2000
Ultimate elongation (per cent)	380	450	8000
Proportional limit (psi)	1100	1700	1800
Yield stress (psi)	1600	1800	1800
Yield strain (per cent)	60	14	9
Flexural modulus (psi)	54,000	150,000	170,000
Compressibility (6) (per cent)	20	10	10
Recovery (per cent)	70	50	40
Deformation under load (5) (per cent)	2.3	1.6	1.8
Flex life (cycles)	7 million	60,000	1000
Permeability to carbon dioxide gas (2)	6	0.8	0.2
Tensile impact strength ft-lb/sq in.	400	300	150
Hardness, Scleroscope	65	36	25
Hardness, Rockwell J	90	85	80
Flexural creep	20,000 (7)	60,000 (7)	60,000 (7)
Characteristics	—0.09 (8)	—0.05 (8)	—0.06 (8)
Dielectric strength (4)	620	620	620

See footnotes for Table 7.

high crystallinity levels are feasible, since the problem of removing heat rapidly (when sintering or annealing) has been greatly minimized. For instance, the crystallinity content of skived tape can be adjusted by an annealing step after the skiving operation if desired. This additional step is usually not required, but it can be done at added cost.

In some operations, such as hot coining, low crystallinity can be obtained by cooling the mold, which has a "quenching" effect on the molded part. This is particularly true in production of diaphragms for valves and other mechanisms, since increased flex life can be obtained with a lower crystallinity level.

Normally, Teflon 1 is molded or ram extruded. Only Teflon 6 can be paste extruded. In thin sections less than ⅛-in. in least dimension, the entire piece can be cooled rapidly to obtain a low crystallinity. In thicker sections, the inner material is insulated by the outer skin and consequently cannot be cooled rapidly. Crystallinities of 56 to 62 per cent are obtained in these thick sections even when rapidly cooled, depending upon total thickness.

An indication of cooling rates and crystallinities that are obtained practically is given in Table 15.

In most applications a low-crystalline material is desirable. Only flexural modulus, impermeability, and ultimate elongation (not elongation at yield) are appreciably improved with increased crystallinities. Flex fatigue life, tensile impact strength, and elongation at yield are markedly improved with a low-crystalline material.

In the rest of the articles in this series, physical properties are plotted in graphical form to illustrate quickly how these properties change with crystallinity. For the convenience of the designer, a "recommended design range" of crystal-

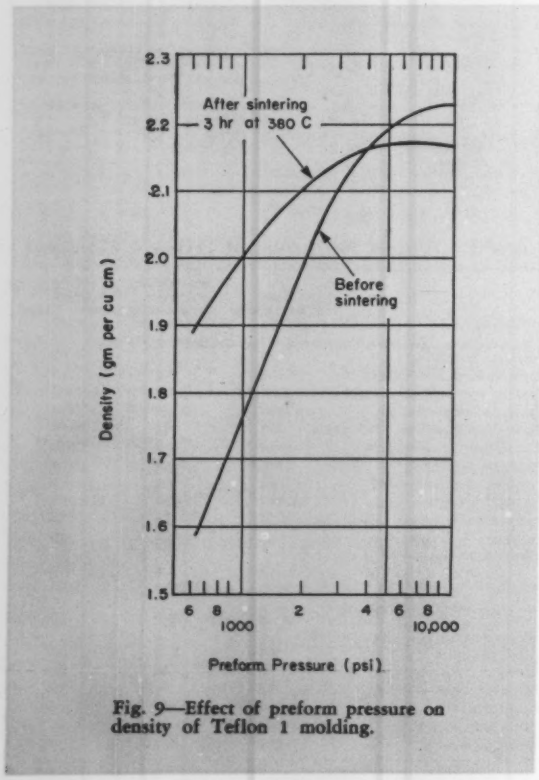


Fig. 9—Effect of preform pressure on density of Teflon 1 molding.

Table 9—Yield Stress of Teflon 1 Moldings
(Values in psi)

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Coined	Preformed at 5000 psi: Slow Cooled	Quenched	Coined
Sintering time ½-hr						
644	*	*	....	*	*	....
680	2000†	1860	....	1960†	1940	....
752	1600	1720	....	1850	1790	....
824	1520	1770	....	1650	1800	....
Sintering time 1½ hr						
644	*	*	....	1780	1710	....
680	2000†	1990	1850	2010†	1780	1900
716	1950†	....	....	1940	....	....
752	1840	1660	1850	1900	1680	1820
824	1460	1530	1540	1570	1540	1620
Sintering time 3 hr						
680	2050†	1890	....	1960	1840	....
752	1890	1890	....	1840	1860	....
824	1420	1400	....	1530	1730	....

4 x 5 x 1/16-in. molded sheets. *Did not cold draw. †Point of inflection; no point on stress-strain curve has zero slope.

Table 10—Elongation at Yield Point of Teflon 1 Moldings
(Values in per cent)

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Coined	Preformed at 5000 psi: Slow Cooled	Quenched	Coined
Sintering time ½-hr						
644	*	*	..	*	*	..
680	80†	78	..	76†	76	..
752	66	66	..	63	66	..
824	23	68	..	19	50	..
Sintering time 1½ hr						
644	*	*	..	50	54	..
680	85†	73	64	88	76	65
716	68†	..	..	78	..	..
752	68	68	64	71	66	60
824	13	57	60	11	58	56
Sintering time 3 hr						
680	80†	75	..	78†	71	..
752	67	67	..	60	65	..
824	14	58	..	6	55	..

4 x 5 x 1/6-in. molded sheets. *Did not cold draw. †Point of inflection; no point on stress-strain curve has zero slope.

Table 11—Ultimate Strength of Teflon 1 Moldings
(Values in psi)

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Coined	Preformed at 5000 psi: Slow Cooled	Quenched	Coined
Sintering time ½-hr						
644	1520	1280	....	1460	1550	2800
680	1980	1850	....	2420	2240	....
752	1560	2290	....	1960	2400	....
824	1330	1770	....	1630	1830	....
Sintering time 1½ hr						
644	1620	1540	....	1780	1730	....
680	2320	2610	2650	2330	2850	2800
716	2190	....	....	2460	....	....
752	1960	2300	2540	2120	2560	2640
824	1330	2480	1920	1390	2300	2320
Sintering time 3 hr						
680	2320	2600	....	2740	3090	....
752	1990	2300	....	2230	2850	....
824	1220	1320	....	1080	2310	....

Microtensile specimens, 3/16 x 0.060 x ⅞-in. gage length. 5 in./min crosshead rate. Values are approximately equivalent to ASTM D 412-C.
Note: 4 x 5 x 1/16-in. molded sheets.

linity (50 to 75 per cent) has been included on each graph. While it is possible under special processing conditions to obtain crystallinity values above and below this range, it is recommended that designs be based on physical properties within this range and preferably within the ranges suggested by Table 15.

Where physical properties are required outside of the recommended crystallinity range, the designer should collaborate with a processor to establish the commercial availability of the crystalline content before proceeding with final design.

Solving Problems: Measurement of specific gravity can be a powerful tool. Suppose the flex life of a batch of molded diaphragms fails to meet specifications. From Table 5, a loss in flex life can result from an increase in crystallinity, a decrease in molecular weight after sintering, or an increase in void content. Suppose the specific gravity of these diaphragms is found to be lower than normal. This probably indicates porosity, indicating a low preforming pressure. On the other hand, a higher-than-normal specific gravity might indicate increased crystallinity caused by either a decrease in rate of cooling, or by degradation at a higher-than-normal sintering temperature.

Table 12—Flexural Modulus of Teflon 1 Moldings

(Values in 1000 psi)

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Coined	Preformed at 5000 psi: Slow Cooled	Quenched	Coined
Sintering time ½-hr						
644	77	61	..	85	72	..
680	84	60	..	86	61	..
752	93	58	..	91	65	..
824	121	67	..	134	96	..
Sintering time 1½ hr						
644	79	69	..	78	65	..
680	73	58	71	74	62	73
716	77	..	..	87	..	..
752	81	62	82	83	66	66
824	128	55	55	136	70	68
Sintering time 3 hr						
680	94	66	..	87	64	..
752	102	68	..	113	74	..
824	128	62	..	134	77	..

ASTM-D-790. 4 x 5 x 1/16-in. molded sheets

Table 13—Ultimate Elongation of Teflon 1 Moldings

(Values in per cent)

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Preformed at 5000 psi: Slow Cooled	Quenched
Sintering time ½-hr				
644	20	20	20	40
680	150	140	200	190
752	90	240	160	240
824	140	220	260	280
Sintering time 1½ hr				
644	40	40	60	60
680	180	240	180	250
716	..	..	..	..
752	180	240	200	260
824	80	360	160	340
Sintering time 3 hr				
680	200	240	270	280
752	180	260	250	290
824	120	150	100	390

Note: 4 x 5 x 1/16 in. molded sheets. Microtensile specimens 3/16 x 1/16 x ⅜-in. gage length. Crosshead rate 5 in./min.

Here is another case. There has been a long-recognized need for a simple method of molding inserts in tetrafluoroethylene by direct preforming and sintering. Inserts are usually press-fitted into undersized holes or, alternately, anchored by hot-forming a sintered molding around the insert. Inserts preformed in polytetrafluoroethylene and then free-sintered, that is without external pressure, are loose after sintering.

Data in Fig. 9 show that, at preforming pressures in the range normally used for small moldings (3000 to 10,000 psi), preforms usually are as dense or denser than the molding after sintering. Under these conditions, the sintering process results in a net volume increase, so it is natural for the molding to loosen away from an insert molded within it. By similar reasoning, one would deduce that if the preforms were pressed at relatively low pressures to give relatively low preform densities, the sintering process would result in a volume decrease and the insert would be held under a strong compressive stress.

This is the basis for a method of molding inserts, which has also been used successfully to encapsulate a transformer. Although the technique works with the general-purpose granular molding powder, better results are achieved with smaller particle-size molding powders. The improvement lies in the fact that preforms with a density as low as 1.9 will sinter into well-fused moldings.

Next Article: The next article in this series will consider several properties of Teflon tetrafluoroethylene plastics: (1) strength and stiffness, and (2) creep, cold flow, and stress relaxation.

Table 14—Dielectric Strength of Teflon 1 Moldings

Temp. (F)	Preformed at 2000 psi: Slow Cooled	Quenched	Coined	Preformed at 5000 psi: Slow Cooled	Quenched	Coined
Sintering time ½-hr						
644	296	275	...	463	438	...
680	294	263	...	422	405	...
752	210	250	...	295	281	...
824	230	224	...	345	326	...
Sintering time 1½ hr						
644	360	311	...	402	384	...
680	352	...	322	385	...	454
716	300	...	...	396	...	...
752	298	...	311	345	...	353
824	278	...	246	296	...	258
Sintering time 3 hr						
680	285	279	...	473	467	...
752	281	279	...	387	384	...
824	202	235	...	316	329	...

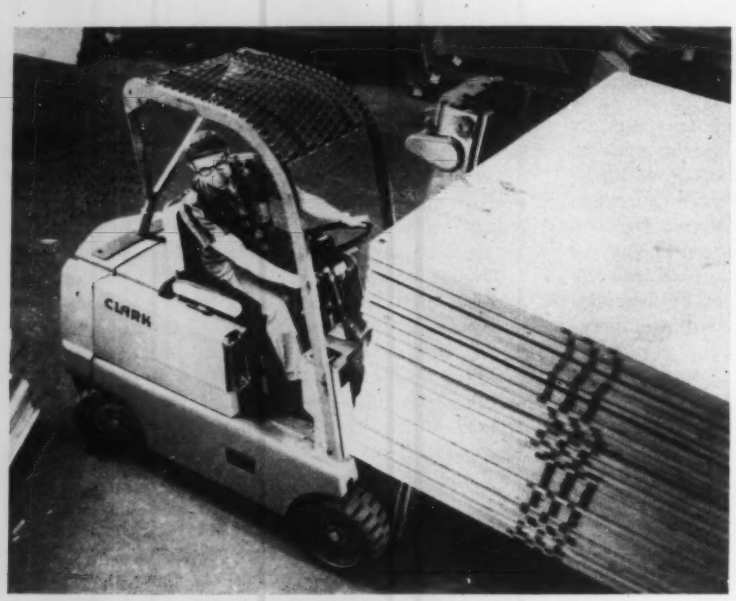
4 x 5 x 1/16-in. sheets measured in Primol D using 1-in. diam rounded electrode. ASTM D-149 short-time test.

Table 15—Practical Crystallinity Ranges

Method of Fabrication	Practical Range of Cooling Rates	Typical Crystallinity (per cent)
Molding*	Quenching, to cooling at 45 F per hr	49 to 57
Ram extrusion	Quenching, to cooling at 45 F per hr	50 to 57
Paste extrusion†	Quenching	50 to 55

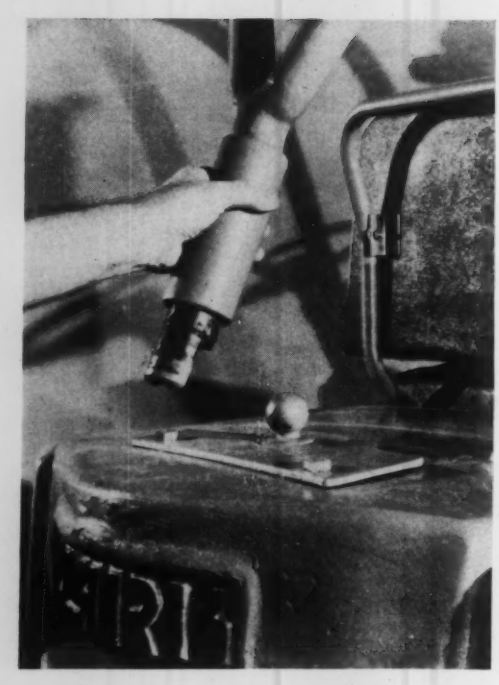
*Coining is a molding technique for cooling rapidly under pressure.
†Only thin sections (less than 0.080-in.) are paste-extruded.

Ball-and-Socket Locking Mechanism Simplifies Removal of Overhead Guard



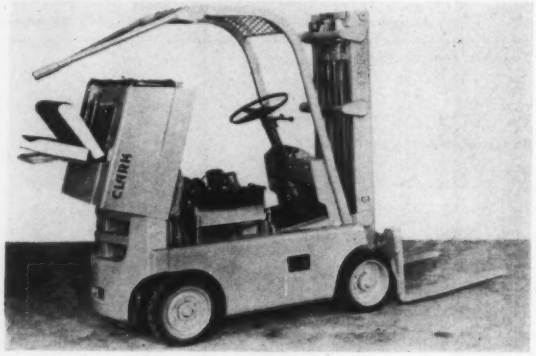
Quick access to fork truck engine is permitted by a novel ball-and-socket locking mechanism. The design is used at the bottom of a spring-loaded strut supporting the overhead guard on the Clarklift line of fork trucks.

Low overall height of guard design allows clearance through a standard 7-ft high opening, yet retains generous headroom. Framework of guard is made of steel tubing, combining high impact and bending strength with low weight. Protection against small falling objects is provided by an expanded metal skin that doesn't restrict visibility of the operator.

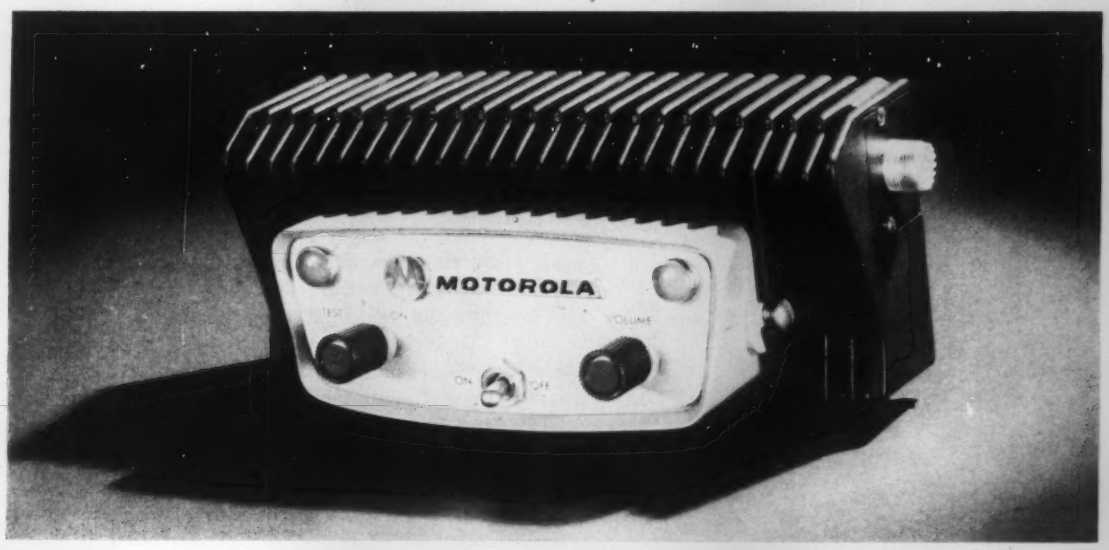


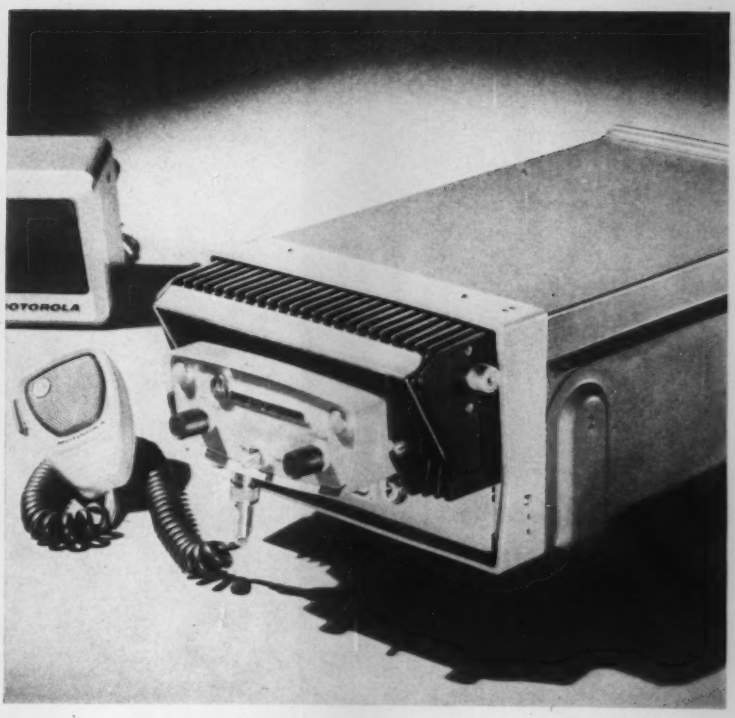
Ball-and-socket latch assembly at bottom of strut support is released by sliding up cylindrical part.

Spring-loaded strut, which serves as the rear support for the guard, swings up and out of the way providing room for the hood to be tilted back during engine-maintenance operations.



Cast Aluminum Fins Cool Transistorized Power Supply

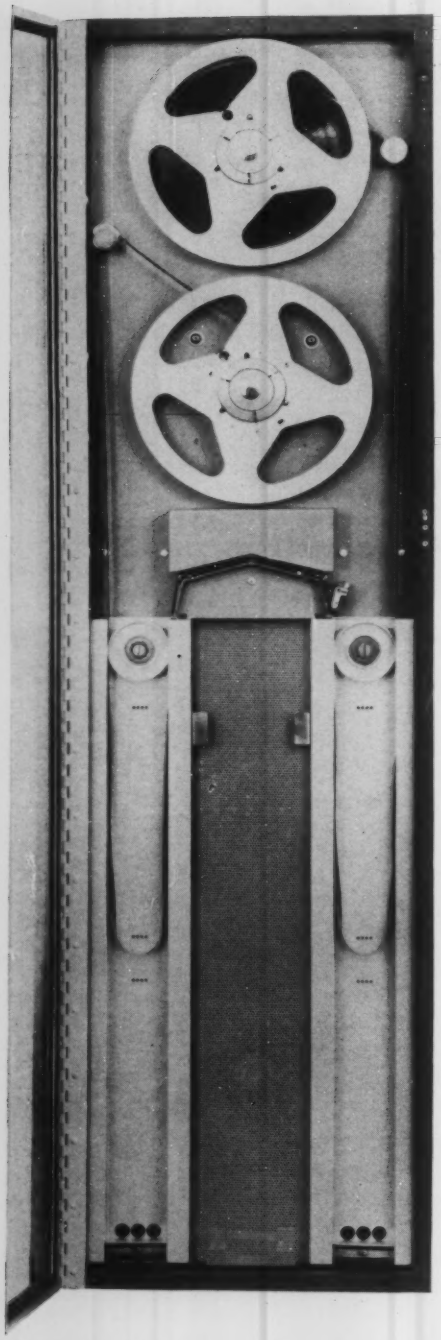




Black-finned radiators serve as heat sinks in Motorola's new line of mobile two-way radio units, which are designed with fully transistorized power supplies. Made of cast aluminum, the fins conduct heat away from two heat-sensitive germanium power transistors in the power supply. Heat is transferred from the mounting base of the transistors to the cooling fins.

The heat-sink fins are not designed to dissipate heat from the whole set although some heat from the rest of the radio is radiated by the sink.

Two Multispeed Motors Provide Ten Speeds in Tape Transport



Tape-drive speed can be varied over a range of 60 to 1 in the ElectroData model 546-53368 digital magnetic tape transport. The machine can operate on any one of 10 closely regulated tape speeds by remote or local control. Speeds are 1.5, 2.25, 3, 4.5, 9, 15, 22.5, 30, 45, and 90 in. per sec.

Tape is ¾ in. wide and is wound on two 10½-in. reels. Start-stop time is 6 millisec. Oxide surface of the tape touches only three stationary members, one of which is the magnetic head. During the rewind operation, the tape is automatically removed from the head.

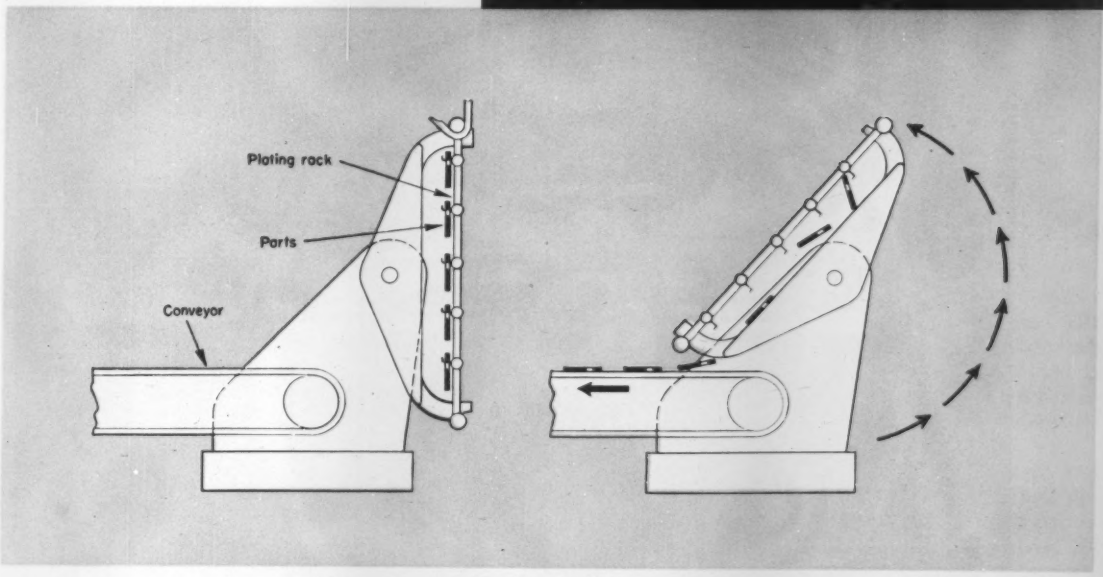
Tape drive system consists of a single pinch-roller assembly, controlled by a high-speed moving coil actuator. Two five-speed motors are used to drive the capstan. The pinch roller is moved 0.006 to 0.008 in. to press the tape against the capstan for any of the speeds.

The vacuum-controlled tape reeling system is operationally independent of the tape drive system. Each reel is driven by a separate motor through a reduction gear. Vacuum sensing switches are associated with each motor, varying motor speed to prevent accumulation of tape in either of the columns adjacent to the read/write head in the machine.

Automatic Parts Unloader Operates Like See-Saw

Through a novel back-and-forth rocking action, a new unloader for plating machines automatically removes plated parts from hook type holders. The unit, which was designed by Wagner Bros. Inc., Detroit, Mich., is shown without back cover or slide that guides released parts to conveyor.

Sequence of operations begins with the unloader grasping and removing a rack load of parts from the drying station. Through a hydraulically operated linkage system, the load is tilted forward through a 120-deg arc and the plated parts fall off their hooks onto a slide which guides the parts down to a moving conveyor belt. The rack is then returned to the machine for its trip to the loading station via two processing baths.



Pushbutton Drive Controls Located in Steering-Wheel Hub

In the new Edsel, the automatic transmission is controlled by pushbuttons which are mounted around the center of the steering-wheel hub. The major advantages of this drive-selector control location are minimum movement of hand and arm to select drive gear and an unobstructed view of pushbuttons and their designations.

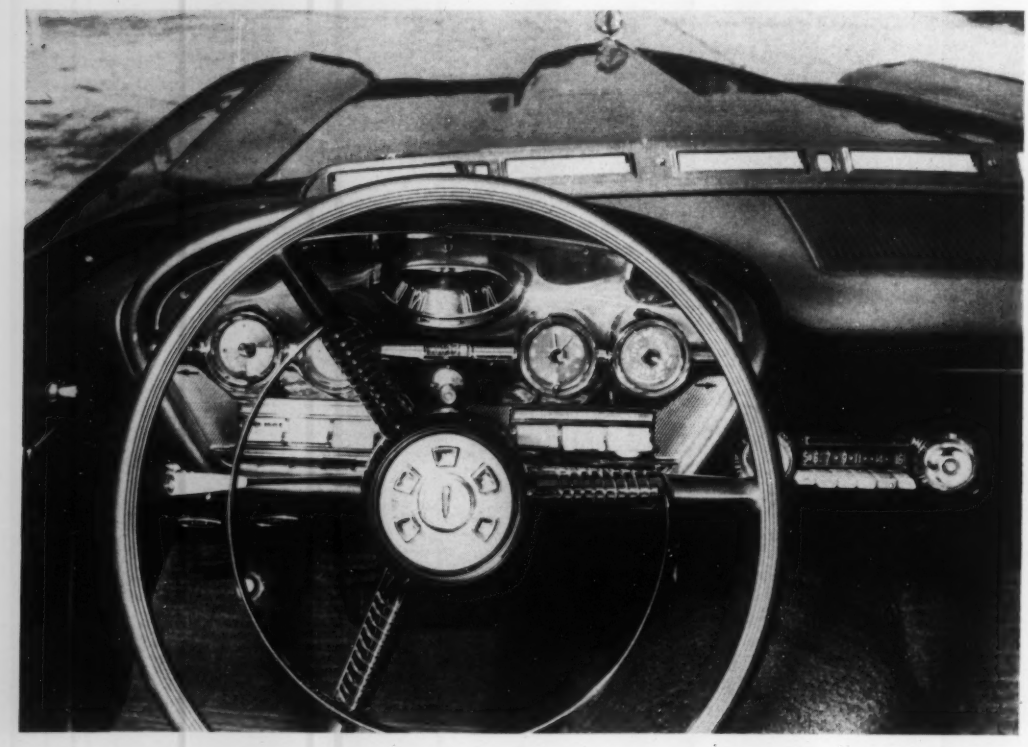
In operation, an electric servomotor selects the required gear when the driver depresses one of five Teletouch pushbuttons. A built-in design safety feature prevents engagement of *reverse* or *park* gears at speeds exceeding 3 mph, which is about the speed required to rock car in snow or mud. The engine can be started in either the *park* or *neutral* position. After the ignition has been turned off, it is still possible to engage *park* gear, but once in *park* no other gear can be obtained until the ignition has been turned on.

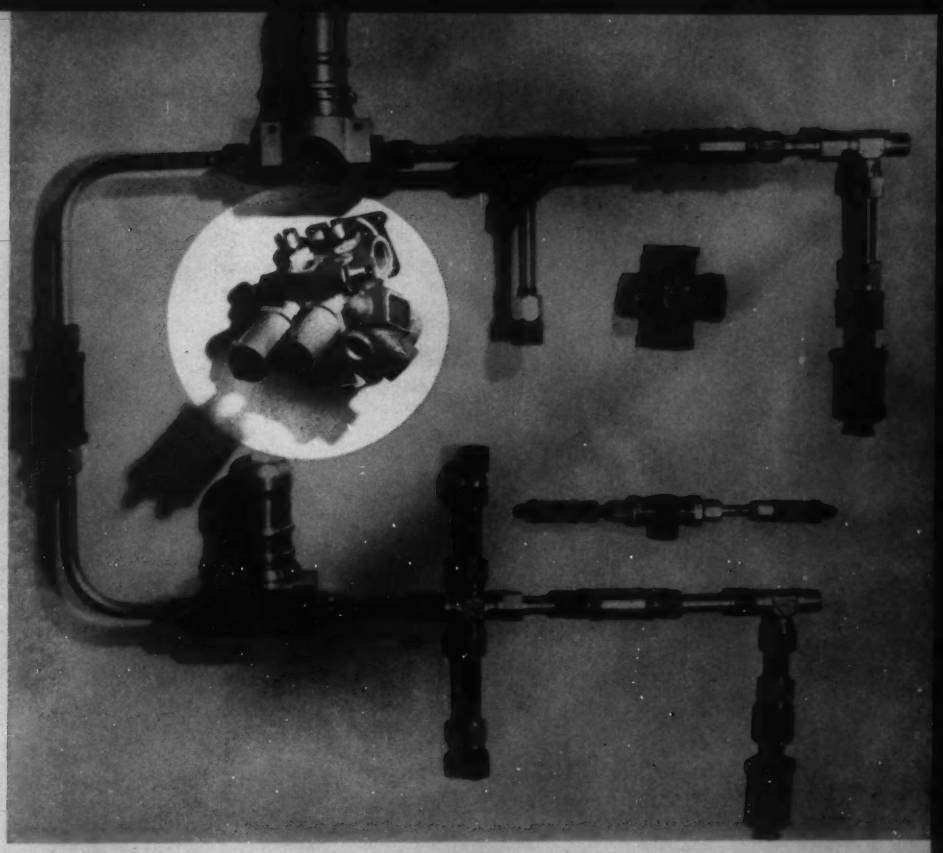
The pushbuttons are indirectly lighted, and the lights are connected with the instrument-panel light-intensity rheostat.

The automatic-transmission pushbutton assembly remains stationary in the steering wheel hub because of a special gearing arrangement around the steering column.

A single-knob heater-ventilator control actuates a servomotor which operates all air vents, heater ducts and the heat control valve. On cars equipped with optional air conditioner, the single-dial control operates both heater and air conditioner.

A floating-drum speedometer resembling a compass is mounted high in the instrument cluster beneath a raised padded cowling.





Weight and volume savings offered by the packaged hydraulic system concept are strikingly illustrated by this Lockheed Electra installation. Incorporating all the surrounding components, the packaged unit weighs only 6.2 lb wet. Weight of all unpackaged components totals 19 lb.

Packaging Hydraulic Components

. . . an approach for reducing system weight and space

By THOMAS F. FITZGIBBON
Manager, Hydraulics Div.
Parker Aircraft Co.
Los Angeles

DESIGN with packaged hydraulic components has the aim of reducing unit and system volume and leads to both substantial weight savings and simplified maintenance practices. Packaging also minimizes the number of interconnected hydraulic, pneumatic and electrical lines with attendant fittings, connectors, joints and other potential trouble spots. Common problems introduced by vibration, high temperatures and pressures, leakage and space restrictions are therefore more easily handled.

Packaged design, however, is not the absolute solution to every hydraulic-system problem. The decision to incorporate it must be carefully studied. Often, timing is of the essence, since packaging is a systems concept and all factors relating to equipment design must receive careful consideration early in the preliminary design stage.

Judicious application of the package concept and a thorough knowledge of hydraulic-component design detail and function are necessary if all potential advantages are to be realized in a given in-

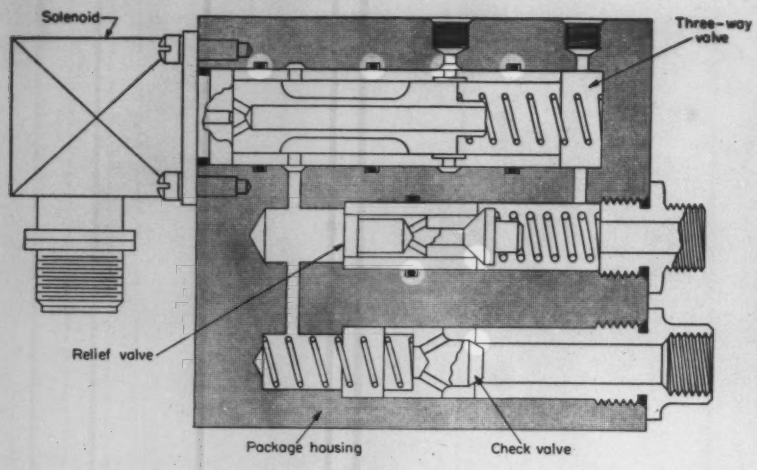


Fig. 1—In the multiple-valve packaging technique, parts making up each separate valve are assembled in a single body. This arrangement is particularly suited for use where units to be packaged are few and simple. Maintenance and test of the multiple-valve assembly are difficult since leakage from the common return port gives no clue as to which valve is faulty. Circles show potential leak points.

stallation. This article outlines the major packaging techniques and gives representative examples of their design use.

Basic Packaging Techniques

Hydraulic units that lend themselves to packaging generally fall into the valve-component class. Pumps, actuators and other units can also at times be incorporated in packaged systems, usually as externally mounted units with ports leading directly into the main package.

In hydraulic-component packaging, one of the main objectives is to reduce line runs by locating all ports and passages in one housing. Such a housing (or mounting plate) is relatively leakproof, and potential leak points are limited to external line connections to actuators and other components. Furthermore, when components are packaged in one housing, weight and size reductions are achieved through the use of "common walls" and through the elimination of extra mounting platforms, clamps and fasteners. Since relatively few packages are required in comparison with the usual large number of individual components, maintenance of such systems is greatly simplified. Individual packages are as easily removed and replaced as are the separate components making up each package.

Valves can be classified by the number of elements they contain: a single-element valve, for example, has one cylindrical subassembly, such as a relief valve or pressure regulator; a double-element valve has two separate cylindrical subassemblies, such as those of a pilot-operated three-way valve. In the latter case, the pilot valve is one cylindrical unit, and the main three-way valve is another.

Four Packaging Methods: Before the application details of packaged hydraulic assemblies are discussed, the general techniques for integrating hydraulic components, known to some degree in industry, are outlined as follows:

1. MULTIPLE-VALVE PACKAGING: Individual parts for two or more valves assembled in the normal fashion in a single body, Fig. 1.
2. CARTRIDGE-VALVE PACKAGING: Two or more cylindrical valve assemblies incorporated in a single body or manifold, Fig. 2.
3. SUBPLATE-VALVE PACKAGING: Attachment of two or more completely housed valves to a manifold in such a manner that all ports lead out of the valve bodies, through their mounting faces, and into the manifold to the system plumbing or to each other, Fig. 3.
4. BANKED-VALVE PACKAGING: A group of similar, flat-sided valve assemblies bolted together in a bank or stack with common porting through the mounting faces from one unit to the next, Fig. 4.

Each of these techniques has advantages and disadvantages. Best system for use depends upon the types and complexities of valves that are to be unified.

Multiple Valves: Where the number of valves is small and the elements of each valve are few and simple, the multiple-valve technique can be used, Fig. 1. Check valves, restrictors, filters and the like fall into this category. However, any attempt to incorporate the elements of several complex valves in a single body by this technique ends in serious assembly, test and maintenance problems. For example, if the parts of half a dozen conventional aircraft four-way selector valves are assembled in appropriately machined bores in a single body, it is impossible to perform a complete test on each individual valve. Excessive leakage from the common return port gives no clue as to which valve is faulty and usually results in complete tear-down.

Cartridge Valves: The valve-section test prob-

lem can be eliminated through the use of cartridge valves although, in general, only single-element valves lend themselves well to this technique. A cartridge is nothing more than a cylindrical cage, within which the individual parts are assembled, Fig. 2. Packings and flow holes are spaced along the cage outer surface in such a manner as to properly mate with passages in the package body or manifold. The cage acts as an intermediate body with the primary function of holding the valve parts together. The assembly can therefore be pretested in a fixture prior to final insertion in the package. The cage may also function as a part of one of the valve elements, such as a port or a seat.

Check valves, resistors and small filters are typical cartridge units. Single-stage pressure and flow regulators relief valves, priority valves, reducers and flow regulators may also be accommodated by this method. More complex valves, such as two-stage regulators, must either be split into more than one cartridge, or arranged in a single cartridge through the use of coaxial, end-to-end elements.

Subplate Valves: Multiple-element valves quite frequently lend themselves better to subplate than to cartridge packaging. For example, a solenoid, pilot-operated four-way valve usually has three elements: two, small solenoid-operated three-way valves and the main four-way valve. In subplate construction, Fig. 3, these elements are assembled into a single body which is bolted to the package mounting face. Mating ports connect valve and subplate passages. A gasket or recessed packing on one of the faces prevents fluid leakage at the joint. Subplate valves can be individually tested before mounting on the rest of the package.

Banked Valves: Banked valves, Fig. 4, are closely related to subplate valves. This technique is usually applied to three or four-way selector valves. Opposite faces of valve bodies are machined flat; pressure and return ports, common to all of the banked valves, mate at adjacent surfaces. Several valves may be bolted together in a stack or bank, and common pressure and common return lines feed them all. One disadvantage of this technique is that, as the number of valve bodies increases, it becomes difficult to obtain sufficient contact force at adjacent faces. This is

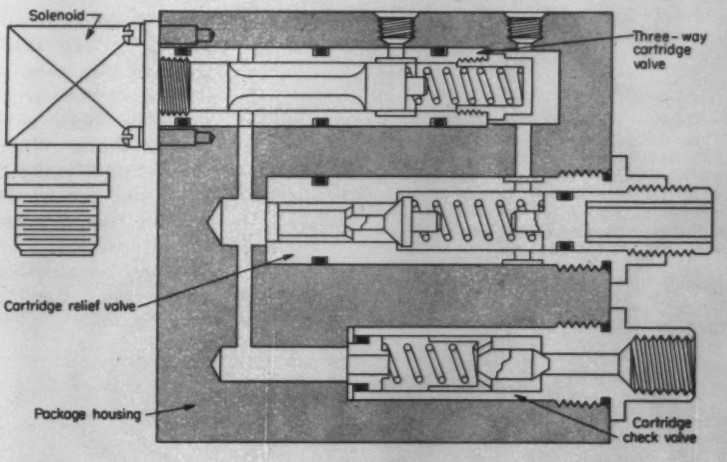


Fig. 2—Cartridged valves have their component parts assembled in a cylindrical cage. The cage forms an intermediate body that can be inserted or removed as a unit from the package housing. Maintenance is simplified since each valve can be carefully pretested before final assembly in the package.

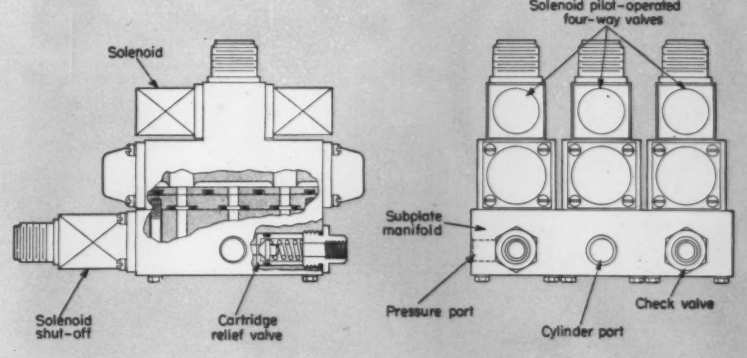


Fig. 3—Three subplate-mounted selector valves mounted on a manifold containing by-pass valves, a relief valve and a check valve. Subplate mounting, which is drilled for fluid passages, can be separated from the valves for test or replacement.

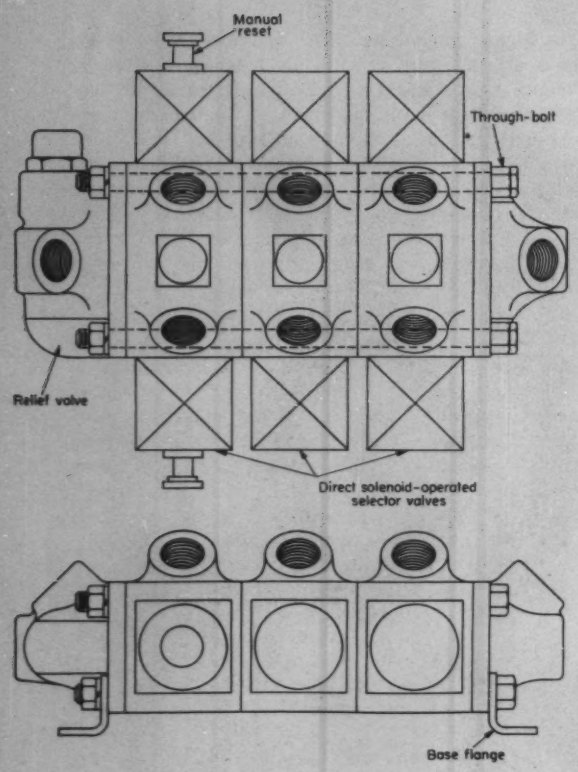


Fig. 4—Banked valves are similar to subplate valves, but do not incorporate a subplate manifold. Adjacent valve-housing faces are machined flat, and mating pressure and return ports are common to all valves. As number of individual valves increases, stretch in through-bolts reduces contact forces between valve mating faces and gives possibility of leakage.

because of excessive stretch in the necessarily long bolts holding the valve bodies together. Maintenance suffers also with the banking technique, since if one valve requires removal, all units must be dismounted.

Combined Techniques

With the growing trend toward the use of packaged systems and the realization of their advantages, it is believed that most future packages will be of the cartridge and subplate-mounted types. Both methods are flexible in application and permit use of standardized components.

It has been pointed out, however, that multiple-element valves are difficult to package as a cartridge assembly. On the other hand, single-element valves lend themselves well to the cartridge technique. Where both valve types are necessary, a combined subsystem package can be designed to contain both plug-in cartridges and subplate-mounted units. The subplate then becomes a manifold for distributing fluid flow. To carry the combination one step further, the subplate itself can also contain a reservoir with the pump either externally or internally mounted. The only hydraulic lines leading away from the package are those connecting the packaged assembly to the external system.

An example of such a combined system is shown in Fig. 5. In this arrangement, the subsystem package also acts as an access door or removable portion of the airplane skin. This system is composed of both subplate-mounted and cartridged plug-in units. When the access door is removed, the complete subsystem is exposed for maintenance check and repair. The door structure also provides a fluid reservoir between the mounting plate and the exterior skin.

Other installations have also utilized the package housing itself as a structural member. For

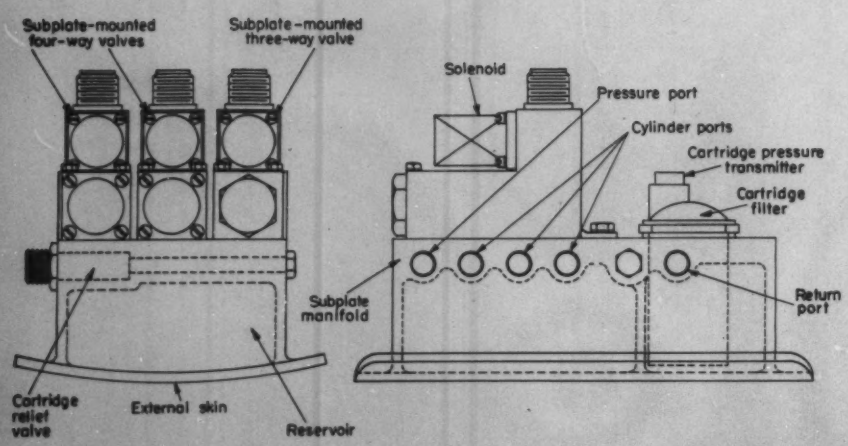


Fig. 5—Combined subplate and cartridge-valve package forms access door of jet-fighter aircraft skin, simplifying maintenance and replacement of the entire assembly or of separate units. Door structure also encloses a fluid reservoir between the skin and the subplate.

example, the aileron-control booster in one of the latest jet fighters, forms part of the wing structure and conforms to the wing curvature.

Practical Applications

A representative example of the packaging technique is that of combining two four-way selector valves used to control individual actuating cylinders in an aircraft gear-retraction mechanism. Since such valves are usually located physically close to each other, they are well suited to packaging. Placing the two valves in a common housing eliminates one pair of pressure and return lines, since one pair can be common. The number of fittings required is also reduced, and use of a single mounting bracket is possible.

In the case of solenoid-operated valves, packaging dispenses with the need for separate wiring, and so a single electrical receptacle can be used. Weight of such a unit can be reduced by one quarter and space required can be reduced by as much as one half, as against the weight of a conventional multicomponent assembly.

The trend toward use of servos to supply power for flight control and to provide aircraft stability stems from the need for power multiplication and synchronous remote control. These operations require accuracy beyond the capability of on-off selector valves. Because servo valve systems are generally safety-of-flight items, their design must be kept simple and reliable. These are requirements that can be best achieved through combination of servo components into a single package. Whenever an external fluid connection can be eliminated, the system is made safer and more reliable.

Components of a servo system lend themselves ideally to the packaging concept, since their design configurations usually embrace interdependent and adjacent components.

In current aircraft hydraulic systems, some use

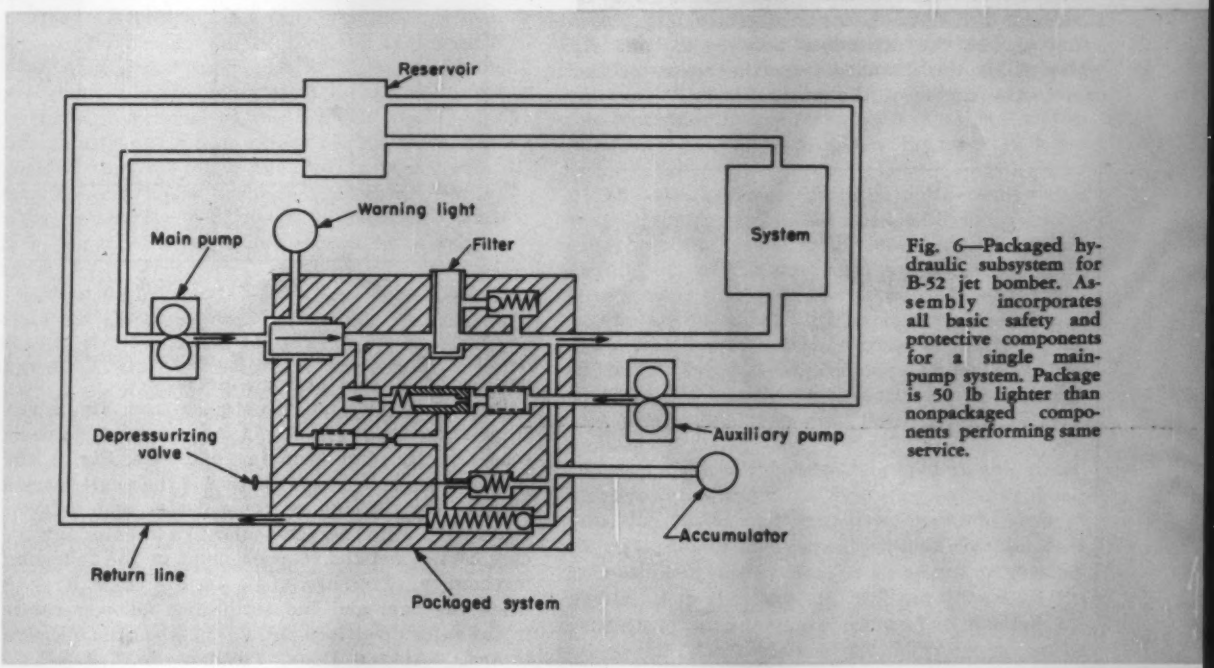


Fig. 6—Packaged hydraulic subsystem for B-52 jet bomber. Assembly incorporates all basic safety and protective components for a single main-pump system. Package is 50 lb lighter than nonpackaged components performing same service.

has been made of the packaging technique. However, it has been almost entirely restricted to the multiple-valve method, where parts of individual valves are assembled in a common housing. Some component banking has also been used. Disadvantage of the multiple-valve techniques lies in the possibility of damaging a complicated and expensive body during installation. Difficulty of servicing is the disadvantage of the component banking technique.

Another recent example of hydraulic-component packaging is a subsystem used on the B-52 jet bomber. This assembly incorporates all basic safety and protective components for a single main-pump system, Fig. 6. Each of the ten identical packaged subsystems combines the following components:

1. Inlet check valve (replaceable in aircraft)
2. Warning-light port
3. Pressure bleed restrictor (to maintain accurate reading of pump pressure)
4. Main-system line filter (replaceable in aircraft)
5. Filter relief valve
6. Main-system relief valve
7. Manual depressurizing valve (to depressurize main system for servicing)
8. Emergency-system control valve (to prevent stalling of emergency motor when starting). This valve by-passes to return line until emergency pump reaches operating speed. Valve then closes return line and flow goes to system outlet
9. Emergency-system check valve
10. Accumulator port

Use of these ten packages reduces the overall system weight by 50 pounds as compared with a non-packaged component assembly.

Tips and Techniques

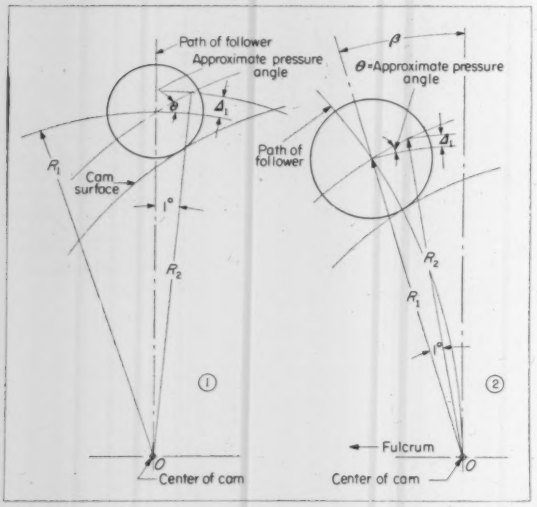
Checking Cam Pressure Angles

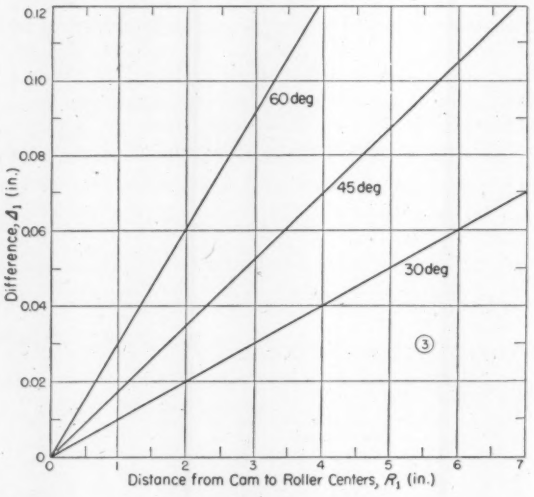
A quick approximate way to determine the pressure angle on two types of cams may be helpful.

The first cam is one which displaces its roller follower in a straight line through the cam center, Fig. 1.

The second cam displaces its roller follower in a circular arc through the cam center, Fig. 2.

Let Δ_1, be the difference between R_2 and R_1 where R_1 is the distance from the center of the cam to the center of the cam follower.





Then tan $\theta = \Delta_1/0.1745\ R_1$ where $\angle R_1OR_2 = 1$ deg and θ = cam pressure angle, deg.

Pressure angles can be obtained from Fig. 3. For translating followers, Fig. 1, the pressure angle is read directly. For swinging followers, Fig. 2, the pressure angle is $\theta \pm \beta$ where β is the angle formed by the line through the cam center and follower center, and a line perpendicular to a line through the cam center and the fulcrum point of the following mechanism. Pressure angle in Fig. 2 is $\theta - \beta$ when the cam and the oscillating follower rotate in the same directions and $\theta + \beta$ when the opposite is true.—ALFRED BECK, *Pomona, Calif.*

The Personal Side of Engineering

By EDWIN C. NEVIS
Personnel Research and Development Corp., Cleveland, Ohio

Reducing Recruiting Costs

IT IS obvious that cost of recruiting an engineer has become exorbitant. Some companies estimate that the cost of putting an engineer on the payroll runs between $1000 and $2500, not including training costs. Such costs can be justified if the people recruited remain with the organization and grow with it. However, recruiters find they are faced with the problem of recruiting men in 1957 to replace men who were hired under "pressure" conditions in 1955 and 1956.

Some light may be shed upon the situation by a survey by the Professional Engineers Conference Board for Industry* on *How to Attract and Hold Engineering Talent*. In this survey, the question was asked, "Was your first job actually as it was described to you at the time you accepted employment?" Twenty per cent of the engineers replying answered "No." Most of these individuals were younger men who entered the profession during the high demand of the last few years. Even more significant is that nearly all these engineers indicated that they are unhappy in their present jobs. It seems quite probable that these men will be very amenable to offers to go elsewhere, creating a demand for additional recruiting of replacements.

Additional evidence from this study clearly points out the problem. For example, 29 per cent did not feel that the company recognized their professional status. Thirty-eight per cent answered "No" to the question, "Do you feel your company is making effective use of your training and ability?" Even more significant is the fact that 38.6 per cent were not satisfied with their present job in respect to two or more factors out of five listed (salary, prospects, nature of work, working conditions, location of work). The great majority were individuals who indicated that they had been "oversold" on their jobs at the time of recruitment.

*Professional Engineers Conference Board for Industry, c/o National Society of Professional Engineers, 2029 K St. N.W., Washington 6, D. C.

These facts are not new to the people who have been grappling with the problem. What to do about it, however, represents a difficult problem. Several things can be quite helpful.

In the first place, to do an effective recruiting job, systematic prior planning is necessary. What does the company require? In many cases, organizations look for more engineers, or for men of greater experience and training, than are really necessary.

Second, and perhaps most important, recruiters must evaluate what the younger engineer deems important in a job. Here, too, studies by the Professional Engineers Conference Board for Industry shed some light. For example, in a study of reasons for entering the engineering profession, 73.5 per cent of the engineers surveyed entered the field because they felt they had engineering aptitudes. This was followed by 16.6 per cent who were motivated by the potential professional status. Financial rewards were given by only 12.3 per cent.

While the evidence indicates quite clearly that many engineers are dissatisfied with their salary, money is not a crucial factor unless a man's salary is really out of line with community levels. What the engineer wants is the opportunity for training and advancement, and enough job security so he can feel free of outside worries and devote himself to the intellectual challenge of his job. The ability to put his talents to work and to be recognized professionally is what really counts to most engineers.

The implication for recruiters is clear and direct. Effective recruiting might best play down emphasis upon the exotic and grandiose possibilities in a job. (Recruiters sometimes overlook the fact that the man being interviewed is as bright or possibly brighter than they are and will not always be impressed by unrealistic promises.) Effective inducements, however, are training programs or

growth assignments that can provide the engineer with several years of opportunity to improve and make full use of his skills.

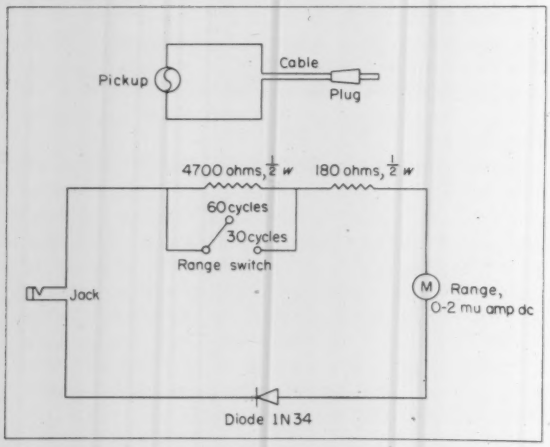
Recruiters who are willing to stick to concrete, down-to-earth aspects of the job, and who are confident enough not to use pressures and blandishments, may find themselves pleasantly rewarded. Such an approach may result in fewer recruits but would appear to bring in pepole who are likely to remain with an organization and who will be more interested in their work than in the fringe benefits.

The engineer, on the other hand, may well benefit from taking a critical attitude toward "fringe" recruiting inducements. A young engineer's decision might also be based on his long-range chances of advancement through training and development rather than on immediate rewards which appear to be out of line with the contribution he is able to make at an early stage of experience.

Tips and Techniques

Portable Vibration Meter

A lightweight "go, no-go" type vibration meter can be a big help in measuring vibration at multiple points. The meter described here is a velocity



type weighing only 3.5 lb instead of the 15 lb for conventional vibration survey meters. It is particularly useful for checking rotary-equipment vibration, particularly motors.

An International Research and Development Corp. model 543 pickup, cable, and meter box with carrying strap comprise the whole setup. The pickup provides the necessary emf; a power source is not needed.

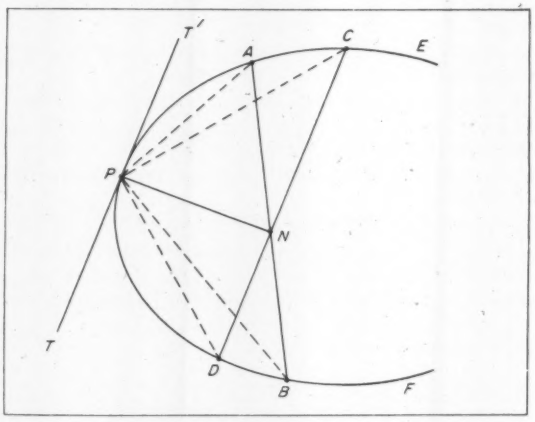
Vibration at two frequencies, 30 and 60 cycles, is measured by flipping a range switch. Meter scale is graduated in five color-coded segments. Each represents a 0.001-in. displacement increment, making the instrument range 0 to 5 mils. Reading is taken to the nearest mil. Indicating pointer oscillation is negligible.—C. H. ERWAY, *Goodyear Atomic Corp., Portsmouth, Ohio (now with U. S. Steel Corp., Gary, Ind.)*

Erasing Small Areas

Strips about $\frac{1}{8}$ by $\frac{1}{2}$ by 1 in. cut from standard erasers and held in a wire-spring clothespin are handier than use of erasing shields for removing pencil lines in "ticklish" locations on drawings. —V. L. DURRSTEIN, *assistant chief engineer, White Diesel Engine Div., White Motor Co., Springfield, Ohio.*

Tangent to Conic Curve

An exact tangent to any conic curve—parabola, ellipse or hyberbola—can be constructed with a minimum amount of simple geometric layout work. In the illustration, *EPF* is any conic curve. The tangent is to be constructed at point *P*. From point *P*, any two perpendicular lines, *PA* and *PB*, are laid out, intersecting the curve at points *A* and *B*. A second pair of perpendicular lines, *PC* and *PD*, intersect the curve at pionts *C* and *D*. Lines *AB* and *CD* are constructed, crossing at *N*. A line joining points *P* and *N* is normal to the point of tangency, and a line perpendicular to *PN* is a tangent, *TT'*.—ANTHONY ERLICH, *Westinghouse Airbrake Co., Swissvale, Pa.*



Mechanics of Vehicles—8

Longitudinal Stability

By JAROSLAV J. TABOREK*
Development Engineer
Towmotor Corp.
Cleveland

dynamic moments •
static moments •
axle reactions •
moments of inertia •

STABILITY against tipping—in either lateral or longitudinal directions—is an essential characteristic of any well-behaved vehicle. The problem of predicting tipping stability assumes special importance where the vehicle center of gravity is high, or where the vehicle is designed to carry a load outside of its wheelbase. Representative of the latter case are fork lift trucks, loaders, scoops and cranes.

Dynamic and Static Moments

Part 4 of this series (July 11, 1957) dealt with vehicle side tipping on a curve resulting from the action of centrifugal forces. In the following section, stability of a vehicle in straight-line motion is examined and related to the position of its center of gravity. As a special case, stability of a load-carrying vehicle while stationary is also investigated.

Dynamic Stability in the Drive Direction: In the general case, moments affecting the dynamic longitudinal stability of a vehicle are:

1. Static moments of the load and of the empty vehicle on level ground.
2. Static moments due to ground inclination.
3. Moments due to acceleration of the vehicle in the drive direction.
4. Moments due to forces of acceleration on the lifted or lowered load.

One of the worst possible combinations of forces is represented in Fig. 56 where a fork-lift truck is shown being decelerated on a down-hill slope and the load is being decelerated while moving downward. Equilibrium of moments around the front-axle ground-contact point gives the equation:

$$L_f W \cos\theta = L_q Q \cos\theta + H_q Q \sin\theta + \frac{QaH_q}{g} + HW \sin\theta + \frac{Wa H}{g} + \frac{Qa_q L_q}{g} \qquad (108)$$

This equation applies, of course, for the state of balance. In practice, stabilizing moments must be

Nomenclature

a = Acceleration, ft per sec^2
a_q = Load acceleration, ft per sec^2
D = Drawbar pull, lb
f = Coefficient of rolling resistance
H = Height of cg from ground, in.
H_a = Height of action point of the air-resistance force, in.
H_d = Height of the hitch point, in.
I = Polar moment of inertia, ft-lb-sec^2
L = Wheelbase, in.
L_f, L_r = Distances of cg from front and rear axles, in.
M_d = Torque on drive axle, lb-ft
M_e = Engine torque, lb-ft
P = Tractive force, lb
P_f, P_r = Tractive forces of front and rear-wheel drives, lb
R_a = Air resistance, lb
R_g = Grade resistance, lb
R_i = Inertia resistance, lb
R_{it} = Inertia resistance of translatory mass, lb
R_r = Rolling resistance, lb
W_{df}, W_{dr} = Dynamic weights on front and rear axles, lb
ΔW_d = Dynamic weight transfer in driving, lb
α = Angular acceleration, rad per sec^2
ζ = Reduction ratio
η = Transmission efficiency
μ = Road adhesion coefficient
θ = Horizontal slope, deg
σ = Stability factor

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made larger by a stability or safety factor σ, defined as the ratio of the stabilizing to the overturning moment.

Stability can be expressed either as a ratio or as a percentage margin, the two being connected by the relation

$$\text{Stability Margin, per cent} = (\sigma - 1) \times 100 \qquad (109)$$

Rearranging Equation 108 so that every stability influencing factor forms its own group,

$$\sigma = \frac{1}{A + B + C + D} \qquad (110)$$

where

A = Static Level Moments

$$= \frac{QL_q}{WL_f}$$

B = Moments due to Slope

$$= \frac{\tan\theta\ (WH + QH_q)}{WL_f}$$

C = Moments due to Vehicle Acceleration

$$= \frac{a(WH + QH_q)}{gL_f\ W\cos\theta}$$

D = Moments due to Load Acceleration

$$= \frac{a_q\ Q\ L_a}{gL_f\ W\cos\theta}$$

Terms containing grade or acceleration can have either a tipping or a stabilizing effect, depending on the direction of the slope and the direction of the acceleration. Convention for assigning signs is as follows: $+\theta$, downhill; $+a$, braking; $+a_g$, deceleration.

Static Stability: Equation 110 is difficult to work with and requires that values of θ, a and a_g be assumed. In practice, stability is often determined for static level-ground conditions only. In such cases, it is sufficient to know cg locations of the vehicle and of the load. Values of the static stability factor are then selected on an experience basis. Adjustments, of course, are made for each specific application so as to provide sufficient safety margin for anticipated dynamic conditions and horizontal slope.

In Fig. 57, a lift truck is shown in level-ground position. The stability factor is

$$\sigma = \frac{L_f\ W}{L_q\ Q} \qquad (111)$$

which is identical to Equation 110 if interpreted for stationary conditions and level ground.

It is apparent that stability is determined not only by the weight of the load alone but, in addition, by its moment around the tipping point. For a given stability factor, the product of load Q and action arm L_q is constant. Graphically such a relation is represented by a hyperbolic curve, Fig. 57. While values of both variables are theoretically unlimited where the stability effect is concerned, the load magnitude is restricted by the strength of vehicle structural parts, and practical considerations will limit the length of the action arm.

Stability Calculations: The techniques employed in stability calculations are best demonstrated by an example:

Assume that a lift truck has empty weight $W = 12{,}200$ lb and cg location at $L_f = 46$ in. and $H = 30$ in. The nominal load capacity is 11,000 lb at $L_g = 40$ in. The relation between the load and its corresponding permissible distances from the support point is to be determined for a stability margin range of zero (tipping limit), 25 per cent, and 50 per cent.

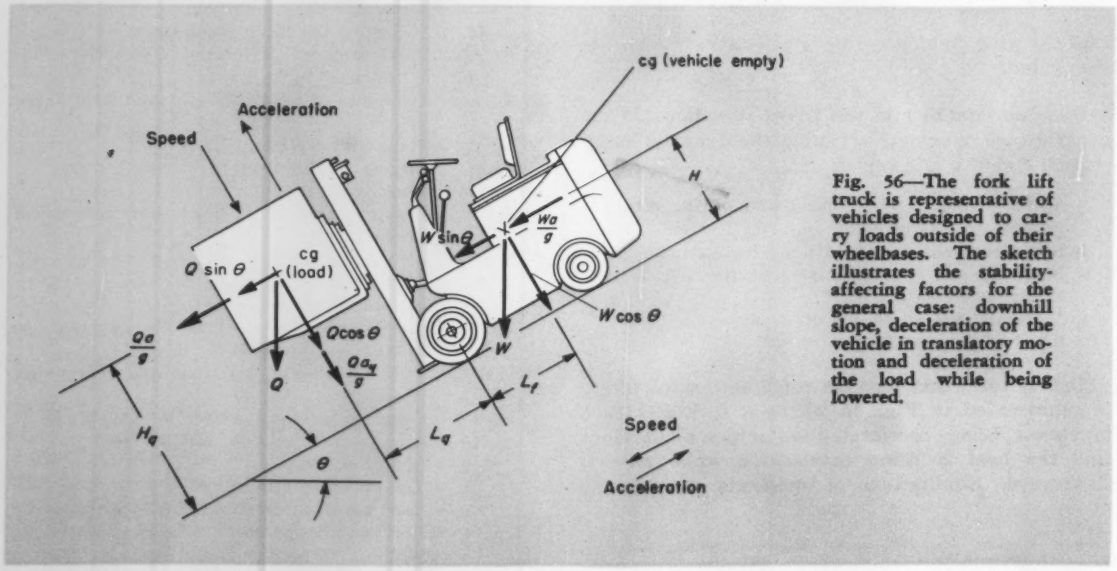


Fig. 56—The fork lift truck is representative of vehicles designed to carry loads outside of their wheelbases. The sketch illustrates the stability-affecting factors for the general case: downhill slope, deceleration of the vehicle in translatory motion and deceleration of the load while being lowered.

STATIC STABILITY ON LEVEL GROUND: The rearranged stability equation is

$$L_q Q = \frac{L_f W}{\sigma} = \frac{(46)(12{,}200)}{\sigma} \qquad (112)$$

From the desired stability margins, the corresponding stability factors, σ, are 1.00, 1.25 and 1.50, respectively. With an assumed series of Q values, the corresponding distances L_q can be calculated. Results are plotted as a family of curves in Fig. 57.

For the nominal capacity of the truck, the stability factor is

$$\sigma = \frac{(46)(12{,}200)}{(40)(11{,}000)} = 1.27 \text{ or } 27\% \text{ margin} \qquad (113)$$

If the absolute load limit Q is 14,000 lb, the truck can carry 6,300 lb at L_q = 70 in. (tips of the forks) and maintain a nominal stability margin of 27 per cent.

STABILITY ON UNBANKED SLOPES AND UNDER DYNAMIC CONDITIONS: For the same nominal capacity data, a stability check will be made for static and dynamic grade conditions. The cg height of the load is assumed variable between 40 in. (load lowered) and 100 in. (load elevated). For the stationary condition, the grade is first calculated for which the truck would tip over (σ = 1). Rearranged, Equation 110 is written as

$$\tan \theta_{max} = \frac{L_f W - L_q Q}{H_q Q + HW} = \frac{(46)(12{,}200) - (40)(11{,}000)}{H_q(11{,}000) + (30)(12{,}200)} \qquad (114)$$

For the assumed conditions, results are as follows:

1. Load lowered (H_q = 40 in.), tan θ_{max} = 0.15 and θ_{max} = 8.5 deg, or a 15 per cent grade.
2. Load elevated (H_q = 100 in.), tan θ_{max} = 0.082 and θ_{max} = 4.79 deg, or an 8.2 per cent grade.

Maximum translatory deceleration of the vehicle at the point of tipping (σ = 1) on level ground is next established. From Equation 110,

$$a_{max} = \frac{g(L_f W - L_q Q)}{H_q Q + HW} = \frac{g[(46)(12{,}200) - (40)(11{,}000)]}{H_q(11{,}000) + (30)(12{,}200)} \qquad (115)$$

Substituting again for H_q, results are as follows:

1. Load lowered (H_q = 40 in.), a_{max} = 0.15 g = 4.8 ft-sec^{-2}.
2. Load elevated (H_q = 100 in.), a_{max} = 0.082 g = 2. 6 ft-sec^{-2}.

Maximum safe deceleration (σ = 1) of the load when it is lowered is

$$a_{q\,max} = \frac{g(L_f W - L_q Q)}{L_q Q} = \frac{g[(46)(12{,}200) - (40)(11{,}000)]}{(40)(11{,}000)}$$

$$= 0.27 \text{ g} = 8.7 \text{ ft sec}^{-2}$$

Any combination of values for grade and acceleration can, of course, be assumed and the actual stability calculated from Equation 110.

Finding Moments of Inertia

There are several occasions in the study of vehicle dynamics where calculation of moments of inertia is required:

1. In the determination of the kinetic energy of rotating parts, such as wheels and tires, gears, flywheels, clutches, crankshafts and connecting rods.
2. In the design of suspension systems.
3. In the calculation of directional stability and curve behavior. In such cases, the inertia moment of the whole vehicle with respect to all three axes is required.

Mass moment of inertia, designated I_m, is defined by

$$I_{(m)} = mk^2 = \frac{Wk^2}{g} \text{ ft-lb-sec}^2 \qquad (117)$$

where k is the radius of gyration. The mass mo-

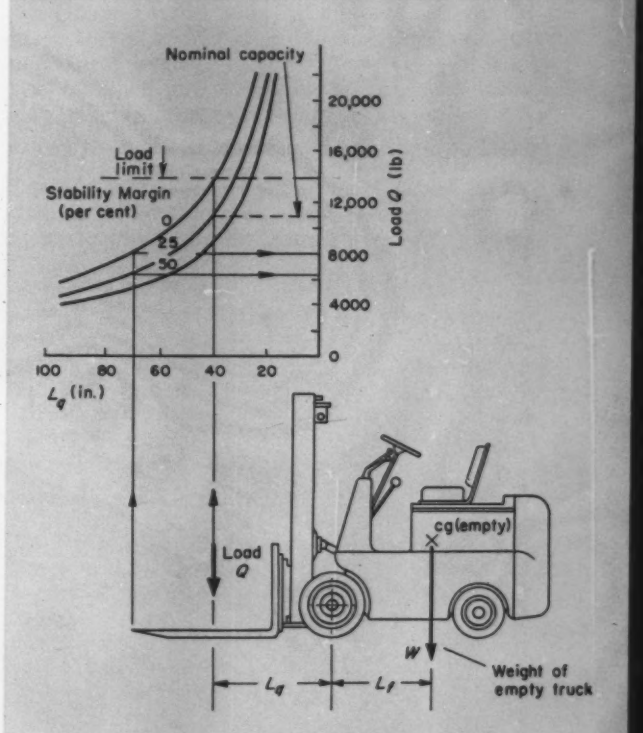


Fig. 57—Capacity-rating technique for a vehicle with load carried outside of the wheelbase. The stability factor σ is defined as the ratio of stabilizing to overturning moments. The relation between the load Q and load moment arm L_q plots as a family of hyperbolas with σ as a parameter.

ment is used commonly in Great Britain and on the continent. In U.S. automotive practice, the weight moment of inertia $I_{(w)}$, which is the product of the weight and the square of the radius of gyration, is widely used. By definition,

$$I_{(w)} = Wk^2 \text{ lb-ft}^2 \qquad (118)$$

Mass and weight moments of inertia are related by the simple relationship

$$I_{(w)} = I_{(m)}g \qquad (119)$$

The moment of inertia of symmetrical parts, for example, wheels and gears, can be calculated by conventional mathematical methods supplemented by sensible approximations. For irregular parts, one of the following experimental methods can be used:

1. Pendulum method, introduced in Part 7 as a means for determining the height of the vehicle center of gravity, can also be used to find the inertia moment around the transverse axis.

2. Torsional oscillation method, used to determine inertia moments around a vertical axis, requires that the body be rigidly fastened at its center of gravity to a torsion wire. For a known twisting moment D (lb-ft per rad) producing unit deflection, the inertia moment can be calculated from the measured oscillation time T. The relationship is

$$I = D\left[\frac{T}{2\pi}\right]^2 \text{ lb-ft-sec}^2 \qquad (120)$$

The value of D for the torsion pendulum can be found by applying Equation 120 to a body of known inertia moment.

3. A third method also uses the weight of the body as an initiating force for torsional oscillations. Suspended freely on two flexible wires of length L, spaced distance A apart, the body of weight W is given a torsional motion of small angular displacement. Time of one complete oscillation T is then measured. The inertia moment around the vertical axis is

$$I = \frac{W}{L}\left[\frac{AT}{4\pi}\right]^2 \text{ lb-ft-sec}^2 \qquad (121)$$

Direct suspension of the body itself is a useful technique for small parts. However, if the inertia moment of the entire vehicle is to be measured, a platform is usually constructed. The inertia moment of the platform is deducted from the calculated inertia moment of the car-platform combination.

Dynamic Axle Reactions

Tractive force between vehicle driving wheels and the ground is a function of the road-adhesion coefficient μ and the effective weight on the driving wheels. When axle reactions are found by weighing or are calculated from the cg position, results apply only for the stationary vehicle. The moving vehicle, on the other hand, is subject to the action of motion-resisting forces which cause a weight shift toward one of the axles. The resulting effective axle reaction is herein designated the dynamic axle weight, and is the factor which ultimately determines the maximum transferable

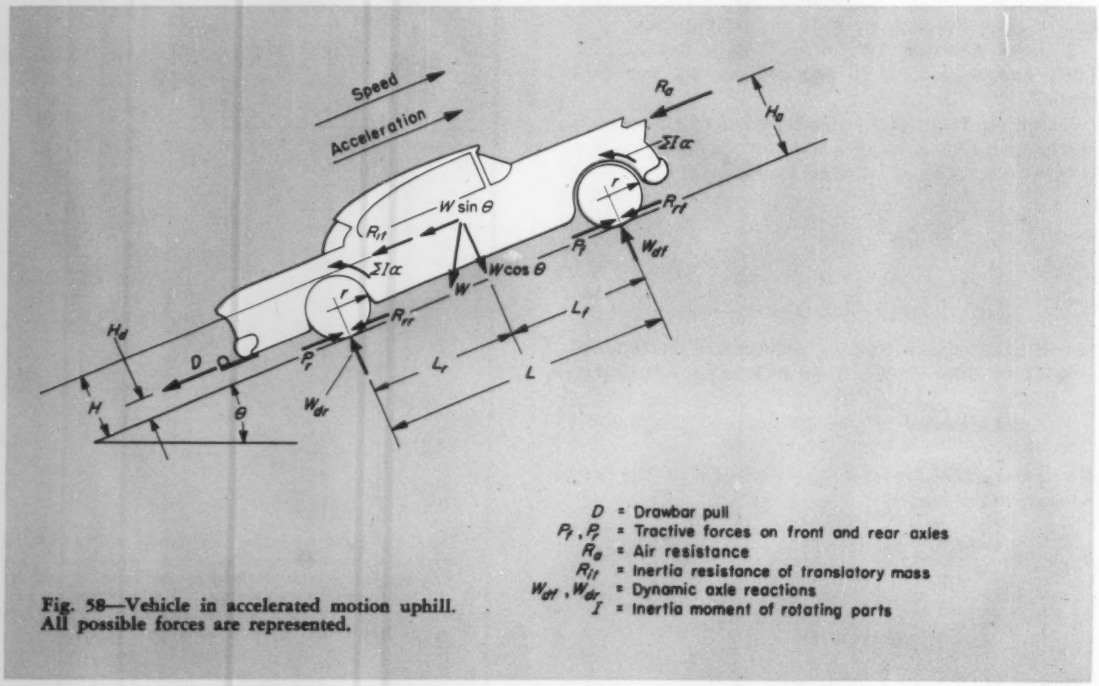


Fig. 58—Vehicle in accelerated motion uphill. All possible forces are represented.

tractive force.

All other vehicle performance factors, such as acceleration, gradability, speed and drawbar pull, depend directly on the available tractive force. In following sections of this article, dynamic axle reactions are examined and are related in the next article to the performance limits of front, rear and four-wheel drive vehicles.

Dynamic Axle Weights: A vehicle in accelerated motion up-hill with all possible forces represented is shown in Fig. 58. Dynamic axle reactions are best determined by forming moment equations around the tire-ground contact points. This procedure eliminates all forces acting in the ground plane. Resulting relationships are

$$W_{df} = \frac{1}{L}\left[L_r W \cos\theta - HW \sin(\pm\theta) - H_a R_a - Hma - H_d D \right] \quad (122.1)$$

$$W_{dr} = \frac{1}{L}\left[L_f W \cos\theta + HW \sin(\pm\theta) - H_a R_a - Hma - H_d D \right] \quad (122.2)$$

$$W \cos\theta = W_{dr} + W_{df} \quad (122.3)$$

where W_{df} is the dynamic weight on the front axle and W_{dr} is the dynamic weight on the rear axle.

Rolling resistance, tractive force and the inertia-resistance torque of rotating parts do not appear in these equations since they form no moment with respect to the tire-ground contact point. By inspection of the equations and from common experience, it is apparent that the weight transfer for the vehicle in Fig. 58 is toward the rear axle.

Results identical to those of Equations 122.1 to 122.3 are obtained when moments are taken around the axle centers. Ground-plane forces, that is, rolling resistance, tractive force and inertia torques of rotating parts, would enter such calculations. Additional moments would therefore be created with the rolling radius of the tire as a lever arm. These additional terms would be canceled out in the final form of the moment equation.

From an analysis of the influences of different forces affecting dynamic axle weight, it is seen that:

1. Weight of the vehicle appears in the normal-to-ground (cosine) component of the grade angle θ. The influence of the cosine factor, however, is usually negligible. For example, for a gradability limit of 30 per cent or 17 deg, the corresponding cosine has a value of 0.96; for the usual maximum road grades of 12 per cent, the cosine equals 0.993. Therefore, in subsequent calculations, the approximation $W \cos\theta \simeq W$ has been adopted. Where the $\cos\theta$ factor still appears, it is only to show relationships in theoretically correct form.

2. The effect of grade resistance R_g is to give a weight increase on the down-hill axle proportional to the sine of the grade angle and to the height of the vehicle cg. The grade angle θ is considered positive if grade resistance is motion opposing (uphill travel). Conversely, grade resistance becomes a motion-promoting force as the grade angle changes sign from positive to negative, since

$$\sin(-\theta) = -\sin\theta \quad (123)$$

3. Air resistance tends normally to increase the rear-axle reaction by a weight proportional to H_a, the height of the air resistance action point. Determination of exact relationships, however, is difficult at high vehicle speeds where air lift forces of unpredictable characteristics appear. Such forces diminish axle weight, particularly on the front axle. To counteract this effect, high-speed vehicle bodies are designed to create a vertical component of the air-resistance force which will balance the lift force and provide further additions to axle weight.

4. Inertia resistance that affects dynamic axle weights is that portion of the total force resulting from acceleration of the translatory vehicle mass. Acting at the mass center of the vehicle, effect of this force is proportional to the height of the cg. The inertia torque of rotating parts, M_t, which can be imagined as a resistance force acting at the ground contact point, is similar to all ground-plane forces in that there is no influence on dynamic axle weights.

5. Drawbar pull D, acting at the hinge point, also increases rear-axle weight by an amount proportional to H_d, the height of the drawbar action point.

For a stationary vehicle, motion-dependent resistance forces disappear, and dynamic axle weights equal static weights.

Simplified Method: While Equations 122.1 through 122.3 are mathematically exact, they are unhandy to work with. This is because air resistance is a function of speed and inertia resistance is a function of acceleration. Furthermore, the state of motion must be known, and the calculation is limited to instantaneous values. A simplification can be introduced by the approximation

$$H = H_a = H_d \quad (124)$$

This implies that all resistance forces are assumed to act at a height equal to that of the center of gravity of the vehicle. Such a condition is very nearly true for the air-resistance force, but for drawbar pull, the approximation should be employed with discretion.

With this simplification, Equations 122.1 through 122.3 can be rewritten as

$$W_{df} = \frac{1}{L}\left[L_f W - H(R_g + R_a + R_{it} + D) \right] \quad (125.1)$$

$$W_{dr} = \frac{1}{L}\left[Lf W + H(R_g + R_a + R_{it} + D) \right] \quad (125.2)$$

From the equilibrium of forces parallel to the ground, the following equation results:

$$P - (R_{rf} + R_{rr}) = R_g + R_a + R_{it} + D \qquad (126)$$

The right side of this equation is identical with the terms in parenthesis in Equations 125.1 and 125.2. Further, total rolling resistance of the vehicle is unaffected by dynamic weight transfer and equals the sum of the front and rear-axle components, or

$$R_{rf} + R_{rr} = R_r = fW \cos\theta \approx fW \qquad (127)$$

When Equations 125, 126 and 127 are combined, an equation results where the dynamic axle weights are a function of the tractive force P, or

$$W_{df} = \frac{L_r W}{L} - \frac{H(P - fW)}{L} \qquad (128.1)$$

$$W_{dr} = \frac{L_f W}{L} + \frac{H(P - fW)}{L} \qquad (128.2)$$

From these equations, dynamic axle weight can be readily calculated for any vehicle operating condition if the tractive force is known. It is of interest to note that the first term on the right side of each equation is the static level axle weight, while the second term represents the actual change in the axle weights, or the so-called dynamic weight transfer ΔW_d. It is also of importance to note that the equations are independent of the state of motion (speed or acceleration), the only variable being tractive force P. Further, the form of motion-resisting forces is unimportant, and the equations are applicable whether the vehicle is equipped with front, rear, or four-wheel drive.

Using the dynamic weight transfer term ΔW_d, the axle weight equations can be written

$$W_{df} = W_f - \Delta W_d \qquad (129.1)$$

$$W_{dr} = W_r + \Delta W_d \qquad (129.2)$$

where W_f and W_r are static level axle weights. For determination of ΔW_d, the value of tractive force P is required. It can be calculated from M_d, the torque on the driving axle which, in turn, is a function of engine torque M_e, total reduction ratio ζ and transmission efficiency η. The expression is

Example 2—Dynamic Axle Weight

A vehicle has gross weight of 3000 lb and is driven by an engine delivering a maximum torque of 200 lb-ft. The differential ratio is 3.9 and low-gear ratio 2.8. Transmission efficiency is assumed as 90 per cent in direct drive and 85 per cent in low gear. The weight is distributed to the axles as follows. $L_f = (0.55)(L)$, $L_r = (0.45(L)$ and cg height H is $(0.35)(L)$. Rolling radius r of the tire is 1.1 ft, and coefficient of rolling resistance f is 0.02.

The dynamic axle weights for max. engine torque output are to be determined for direct drive and for low gear.

Static axle weights are given by the cg location; or

$$W_f = L_r W = \frac{(0.45)LW}{L} = (0.45)(3000) = 1350 \text{ lb}$$

$$W_r = W - W_f = 3000 - 1350 = 1650 \text{ lb}$$

The effective torque on the drive axle, M_d, is found from Equation 130. Results are:

1. In direct drive,

$$M_d = (200)(3.9)(0.9) = 700 \text{ lb-ft}$$

2. In low gear,

$$M_d = (200)(3.9)(2.8)(0.85) = 1860 \text{ lb-ft}$$

The dynamic weight transfer is then calculated from Equation 131. Results are:

1. In direct drive,

$$\Delta W_d = \frac{(0.35)L}{L}\left[\frac{700}{1.1} - (0.02)(3000)\right]$$

$$= 200 \text{ lb}$$

2. In low gear,

$$\Delta W_d = \frac{(0.35)L}{L}\left[\frac{1860}{1.1} - (0.02)(3000)\right]$$

$$= 570 \text{ lb}$$

which is a 42 per cent weight decrease on the front axle, or a 34.5 per cent weight increase on the rear axle over the static load.

Dynamic axle weights are then:

1. In direct drive,

$$W_{df} = 1150 \text{ lb}$$

$$W_{dr} = 1850 \text{ lb}$$

2. In low gear,

$$W_{df} = 780 \text{ lb}$$

$$W_{dr} = 2220 \text{ lb}$$

It is apparent that weight transfer is considerable, especially in high-reduction drive. Results are the same whether the tractive force produces motion acceleration or drawbar pull.

$$P = \frac{M_d}{r} = \frac{M_e \zeta \eta}{r} \qquad (130)$$

The dynamic weight transfer term is then

$$\Delta W_d = \frac{H}{L}\left(\frac{M_d}{r} - fW\right) \qquad (131)$$

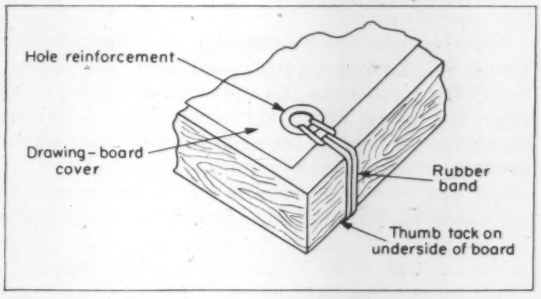
It is seen that the weight transfer term is merely a function of wheelbase L and cg height H; it is independent of cg position and almost independent of weight (fW term is small). Example 2 illustrates the calculation technique.

The next part of this series examines the performance limits of a vehicle, that is, traction, speed, gradability, acceleration and drawbar limits, and relates these factors to the fundamental propulsive force.

Tips and Techniques

Keeping Cover Taut

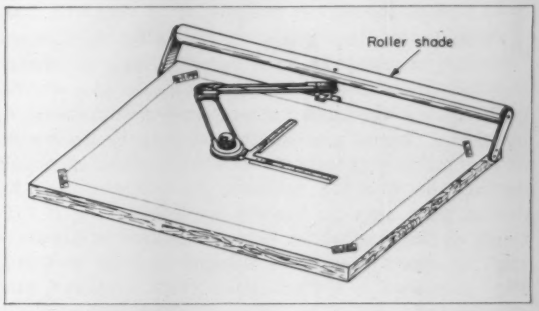
A simple system may be used to keep the cover of a drawing tight and free from ripples caused by changing weather conditions. One end of the cover is fastened semipermanently to the board



with thumbtacks or staples. The opposite end is punched with a series of holes, spaced from 4 to 8 in. apart. The holes are strengthened by a loose-leaf hole reinforcement on each side. One or two rubber bands per hole are then looped through the holes, depending on the size of the board. The free ends of the rubber bands are hooked over thumbtacks on the underside of the board.—D. W. LOUGHLIN, *Cochrane Corp., Philadelphia.*

Drawing Board Cover

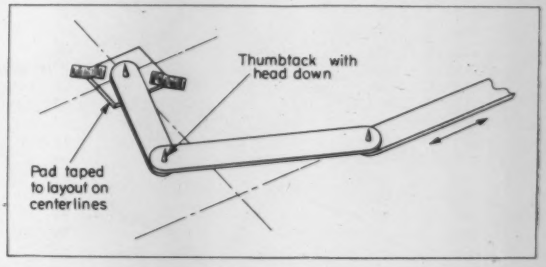
A drawing board cover can be readily devised that is much more convenient than the conventional ones which must be rolled up and stored during the day. The cover consists of a roller shade and a holding bracket. The brackets are short lengths of ⅛ by 1 in. steel. If only one screw is used to fasten each one to the board, the shade and hanger unit can be pivoted after rolling up



the shade so that it will hang below the surface of the board.—CLINT MCLAUGHLIN, *New York.*

Simplifying Mockups

"Paper doll" cutouts or replicas of machine parts such as links, levers or cams are often used to check the length of stroke, movements and clearances of moving parts. If the thumbtacks that are used for pivots are inserted from the bottom of a center-lined piece of file card and



then taped to the drawing, the layout will not be ruined by large holes nor will holes be made in the drawing board.

The expense of using extra boards and extra time is saved when the original layout is used for this purpose.—EDWARD J. KICK, *Columbus-McKinnon Chain Corp., Tonawanda, N.Y.*

Radial Gear Shifting

. . . a method for minimizing angular displacement of driven gear during disengagement.

By Boas J. Popper
Kfar-Ata, Israel

IN SOME gear-train designs, it is required that certain of the gears be radially disengaged while stopped. In such cases, it may be desirable to prevent any displacement of the driven gear during the shifting operation. For example, in special timing mechanisms, it may be necessary to not move a pointer that is in a preset position during the shifting process. At other times the driven gear may be heavily loaded making it difficult or impossible to move. Furthermore, "grating" of gears should be avoided during shifting. Fig. 1 shows a typical gear train engaged and disengaged.

The design requirements of smooth disengagement can be met by calculating the length of the shifting lever arm k in in. from the following equation

$$k = r \frac{1}{\frac{r}{R} - \cos \alpha}$$

where r is the radius in in. of the small intermediate gear C, R is the radius in in. of the large intermediate gear B, and α is the angle in degrees subtended by a line drawn through center of the driving gear A, the intermediate gear pair B and C, and the pivot point K of the shift lever and by an intersecting line drawn through the center of the driven gear D and the center of the intermediate gear pair B and C.

This formula is theoretically true for friction wheels only as long as angle α changes little during the shifting operation. Experience has shown, however, that even significant changes in α do not cause any noticeable displacement of the driven member, even in toothed gears.

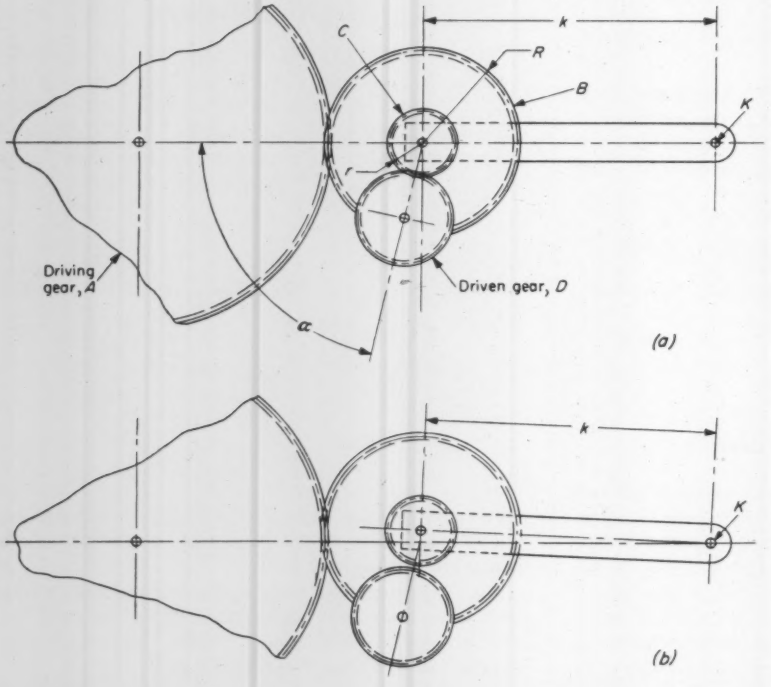


Fig. 1—Gear train with intermediate gear C engaged with driven gear D in *a*, and C and D disengaged in *b*. Proper length of shifting lever arm k will permit "nongrating" disengagement of gears C and D.

Torque-tension charts for selection and application of

Socket-Head Cap Screws

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RELATIONSHIP between tightening torque and tension developed in a screw or bolt has received considerable attention in engineering literature.[1,2,3] Basic theoretical expressions for this relationship are well known but are often difficult to apply without extensive experimentation because of the complex variable quantities involved.

As a simplified approach to this problem in the application of socket-head cap screws, detailed data has been developed on torque-tension characteristic of standard sizes of screws manufactured within ASA specification (*American Standard Socket Head Cap Screws and Socket Set Screws*—ASA B18.3-1954). These data appear on the following pages in the form of 14 empirical torque-tension charts that were obtained from extensive testing conducted at the Mac-it Parts Co.

These charts offer a shortcut to selection of the proper size of socket-head cap screw for specific applications and to specification of tightening torque required to realize full holding power of the screw in assembly. Considerations influencing the use of these charts in design are discussed in the following sections.

Range of Application: The charts presented here cover standard socket-head cap screws ranging from No. 4 through 1-in. nominal sizes, Table 1. Data is based on high-grade alloy-steel screws hardened by quenching in oil from the hardening temperature, and tempered to a hardness of Rockwell C 36-43. Threads are Class 3A.

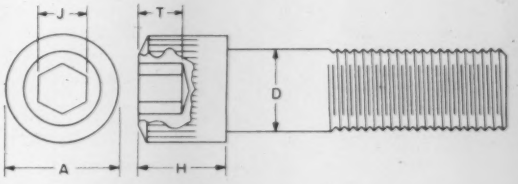
These data apply to the normal assembly of alloy-steel socket-head cap screws in steel parts. Addition of special lubricants, removal of the usual protective coatings, improper tapping of holes, plating on threads, or use in materials other than steel are some of the factors which may affect the torque-tension ratio.

During the tests, screws were tightened both with and without additional lubricants. A heavy lubricant has a noticeable effect on the torque-tension curve in the lower range, but has negligible effect under severe stress. All resultant values reported can be obtained with no more lubricant than that normally left on the screws in manufacture.

The data hold approximately true for both coarse

[1]References are tabulated at end of article.

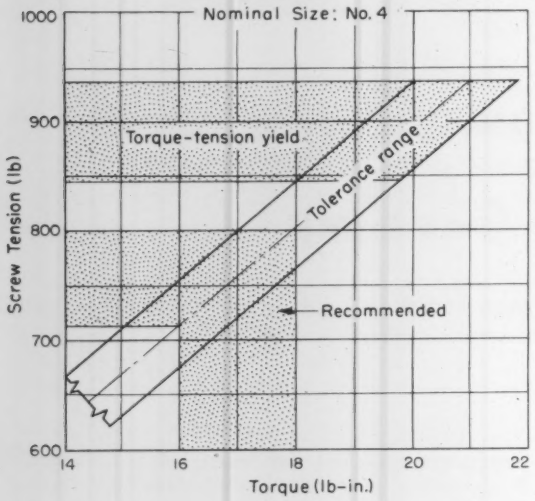
Table 1—Design Details of Socket-Head Cap Screws

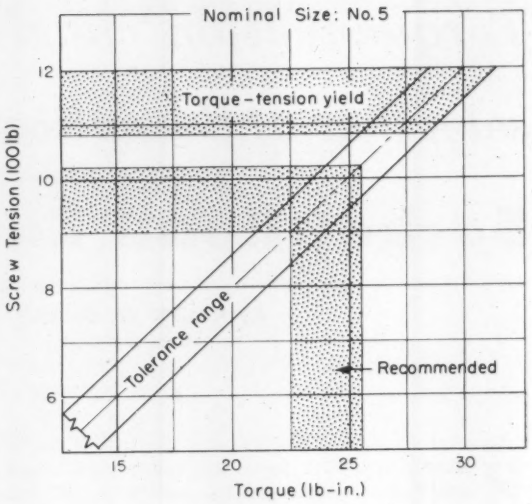


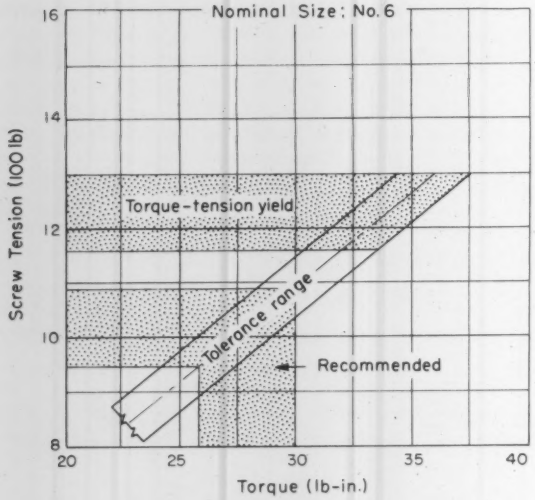
Nom. Screw Size	Threads Per Inch*	Screw Dimensions (in.) A	J	H, D	T	Min. Tensile Yield (lb)	Mean Thread Area (sq in.)
No. 4	40	0.183	5/64	0.112	0.051	1,045	0.00597
4	48	0.183	5/64	0.112	.051	1,140	.00653
5	40	0.205	3/32	0.125	.057	1,380	.00787
5	44	0.205	3/32	0.125	.057	1,440	.00822
6	32	0.226	3/32	0.138	.064	1,580	.00901
6	40	0.226	3/32	0.138	.064	1,760	.01005
8	32	0.270	1/8	0.164	.077	2,430	.0139
8	36	0.270	1/8	0.164	.077	2,560	.0146
10	24	5/16	3/32	0.190	.090	3,050	.0174
No. 10	32	5/16	3/32	0.190	.090	3,470	.01985
¼-in.	20	3/8	5/16	¼	.120	5,220	.0317
¼	28	3/8	5/16	¼	.120	5,970	.0362
5/16	18	7/16	3/32	5/16	.151	8,620	.0522
5/16	24	7/16	3/32	5/16	.151	9,540	.0578
3/8	16	9/16	5/16	3/8	.182	12,740	.0772
3/8	24	9/16	5/16	3/8	.182	14,430	.08745
7/16	14	5/8	5/16	7/16	.213	17,500	.106
7/16	20	5/8	5/16	7/16	.213	19,520	.118
½	13	3/4	3/8	½	.245	23,360	.142
½	20	3/4	3/8	½	.245	26,310	.159
5/8	11	7/8	½	5/8	.307	37,240	.226
5/8	18	7/8	½	5/8	.307	42,120	.255
3/4	10	1	5/8	3/4	.370	53,440	.334
3/4	16	1	5/8	3/4	.370	59,540	.372
7/8	9	1 1/8	5/8	7/8	.432	73,810	.461
7/8	14	1 1/8	5/8	7/8	.432	81,360	.509
1	8	1 5/16	5/8	1	.495	90,800	.605
1 in.	12	1 5/16	5/8	1	0.495	99,310	0.662

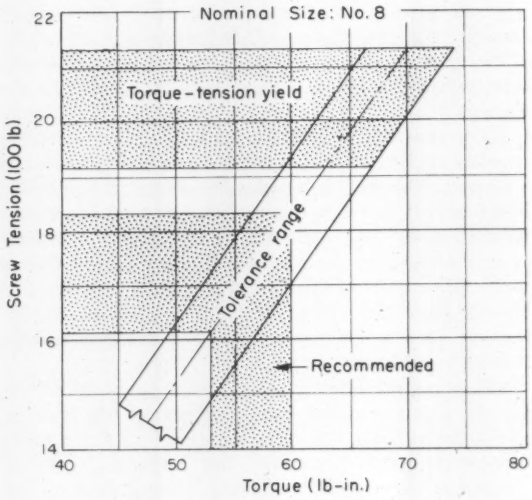
*For each nominal size, smaller number is UNC value, larger number is UNF value.

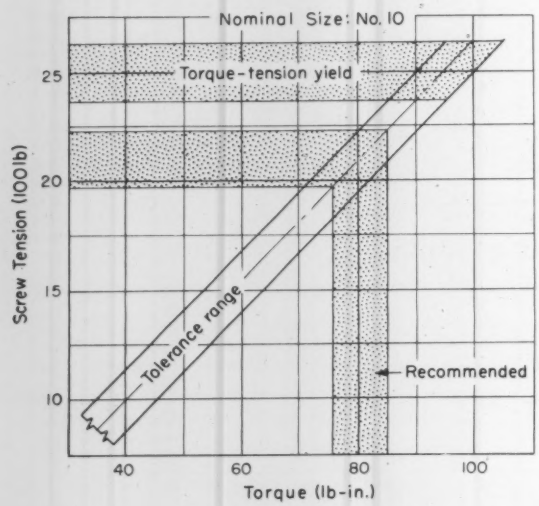
TORQUE-TENSION CHARTS FOR

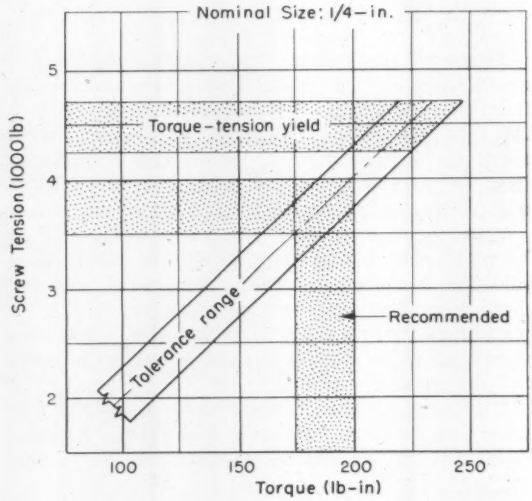




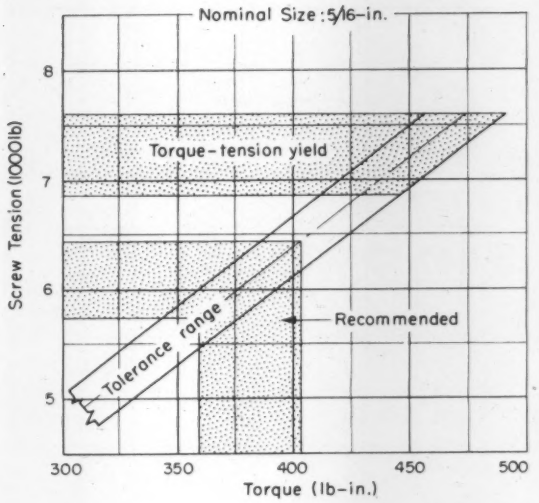


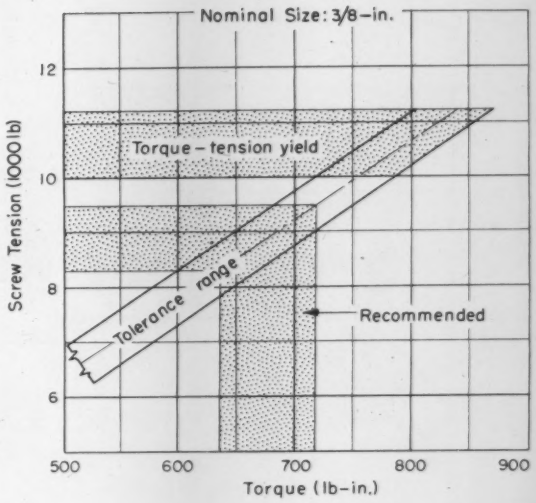


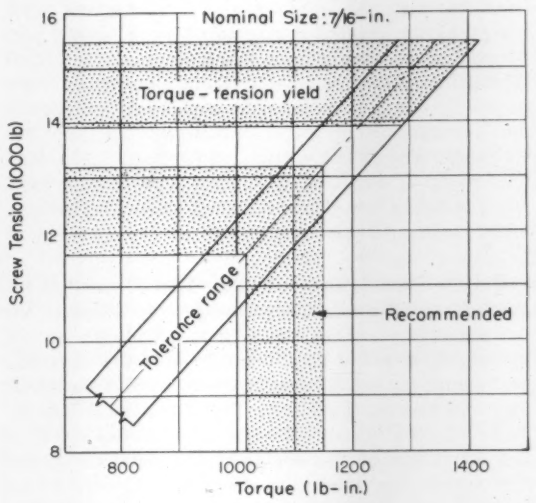


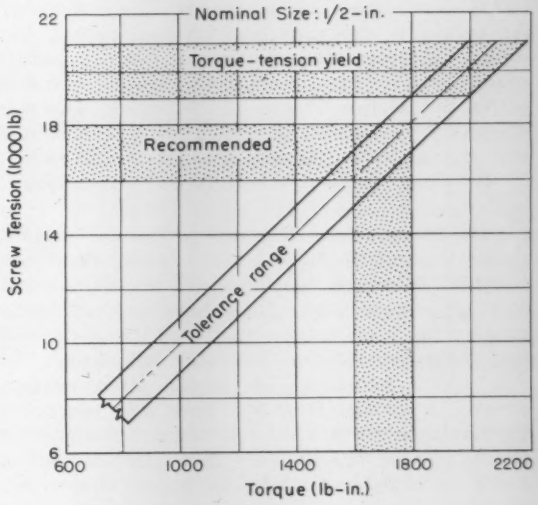


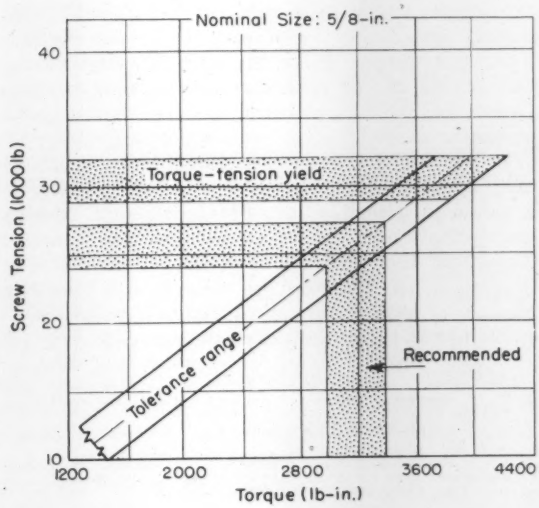
SOCKET-HEAD CAP SCREWS

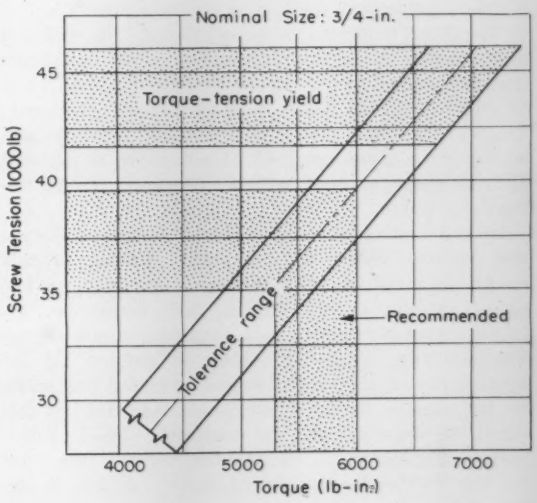




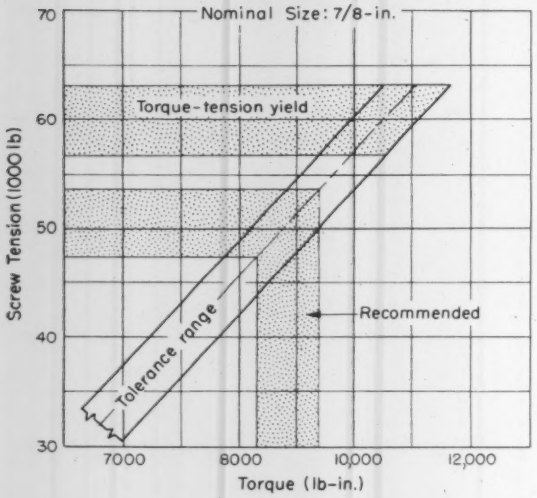


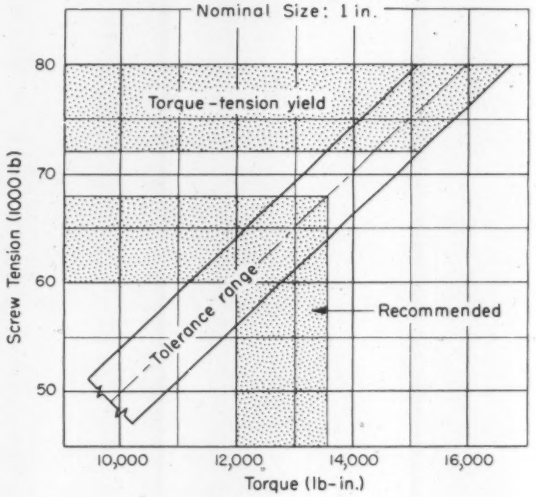






TORQUE-TENSION CHARTS FOR SOCKET-HEAD CAP SCREWS *(continued)*





(UNC) and fine (UNF) threads. Since most of the torque is expended to overcome friction, the slight difference due to thread pitch is small enough so that results for both thread types fall within the tolerance range on the curves. This tolerance range is an allowance, covering both screws and mating parts, for the inherent tolerances in: 1. Materials. 2. Manufacturing. 3. Heat treating.

Data Preparation: The test procedure was designed to duplicate actual conditions as closely as possible. Standard "off-the-shelf" screws selected at random were used. The screws and case-hardened commercial hexagon nuts were then tightened in a Skidmore-Wilhelm Calibrator, a hydraulic device which indicates the actual screw tension directly in pounds. Over 6000 tests were conducted to eliminate variations and obtain reproducible results. These figures were then substantiated in hundreds of other tests where screws were tightened to the recommended torque and produced the desired tension as indicated by the charts.

When the test results were plotted, they showed that tension is an approximate straight-line function of applied torque up to the yield point. This, of course, agrees with Hooke's law of elasticity. The curves thus give the resultant tension generated by a given torque. This tension is resisted by an equal amount of compression in the assembled parts.

In the charts, a recommended range of torque and tension values is indicated. Values in this range fully utilize the inherent strength of the screw, within safety limits, and create an efficient clamping force in normal applications. Theoretically, ideal tightening is defined as the application of sufficient torque to stress the screw to its elastic limit. Since this condition is difficult to achieve on the assembly line, recommended practice is to tighten to 80 per cent of the *torque-tension yield point,* which is defined here as the *amount of actual tension, generated by an applied tightening torque, where permanent elongation of the screw begins.* Note that this point differs somewhat from the tensile yield point, which represents the beginning of permanent elongation under straight pull testing. The torque-tension yield point, as defined here, will always be a smaller value than the tensile yield point because the screw is being subjected to combined shear and tension stresses.

Design Calculations: Before the torque-tension curves can be used, it is necessary to estimate the desired screw stress or tension. This value will usually be dictated by the function of the assembly and should be established in accordance with standard engineering practice. The "factor of safety" to be applied in these design calculations is left to the discretion of the designer, but unusual operating conditions such as vibration, impact loads, fatigue, etc., should be given special consideration. While the ability of a part to resist shear loads varies considerably, depending upon the application, the simple shear strength of socket-head cap screws of the type discussed is normally between 60 to 70 per cent of the tensile yield strength.

In the use of this data, it should be remembered that about 90 per cent of the torque applied to a screw in assembly is used to overcome friction under the screw head and between the threads. Thus, for best results, it is important that the surface under the head be smooth and that the threads of both screw and tapped hole be accurately formed and free of nicks or damage.

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1. W. C. Stewart—"Torque for Bolts and Nuts," *Fasteners,* Vol. 10, No. 1, p. 12.
2. G. A. Maney—"Predicting Bolt Tension," *Fasteners,* Vol. 3, No. 5, p. 16.
3. *Kent's Mechanical Engineers' Handbook, Twelfth Edition—Design and Production,* edited by Colin Carmichael, John Wiley & Sons Inc., New York, 1950, Section 10, p. 57.

Advantages and limitations of

Ultrasonic Machining

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MACHINING rates attainable with ultrasonic reciprocating tools are affected by many factors apart from those quantities fixed by constructional features of the vibrator, i.e., oscillatory amplitude, operating frequency and static loading. Other factors include tool material, shape, area, depth of cut, physical properties of work material, and abrasive properties including hardness, grain dimensions, nature of the suspension medium and concentration of suspension.

Brittleness is the most important single property of the workpiece which determines its machinability as shown in Tables 1 and 2. For the present purpose, brittleness is taken to mean ability to chip pieces up to 0.001-in. in size from the workpiece. Many materials which are ductile and malleable at ordinary temperatures, and therefore not easily machined ultrasonically, become brittle when temperature is reduced sufficiently, so that the technique possesses a considerably wide potential field of application.

Cutting rates are greatest for glasses and certain ceramics. In metals, with the exception of germanium, speeds are lower, generally by a factor of 25 to 100. However, even in tough, hard metals not noted for brittleness, cutting speeds are generally high enough to make ultrasonic techniques applicable. An important advantage of the high-frequency machining technique is that under normal operating conditions it leaves no residual mechanical stresses in material being cut. Even in the most brittle easily-fractured materials, pieces chipped off in the machining process are small compared with abrasive grit dimensions, showing that stresses communicated to the workpiece are extremely localized even though particle acceleration of the tool is generally very great.

Accuracy: Since abrasive grains must necessarily pass down the sides to get under the tool, a resulting hole, for example, will be oversize relative to the tool, the oversize being greater at the entry and getting progressively less toward the exit for through holes. When close dimensional tolerances are required, it must be possible

Table 1—Comparative Cutting Speeds in Metals*

Material	Abrasive→ Boron Carbide 100 mesh	Boron Carbide 200 mesh	Boron Carbide 400 mesh	Silicon Carbide 100 mesh	Alumina 220 mesh	Sand 0.012-in. grit size	Diamond Powder 0.001-in. grit size
Soda glass	100	90	77	85	65	47	90
Brass (common yellow)	6.6	5.6	..	..	..	..	..
Die steels							
K.E. 672 (R 66)	1.4	1.3	..	..	..	..	..
C.S.K. (R 62)	3.9	3.6	..	..	..	..	..
K.E. 672 (R 61)	2.2	2.1	..	1.48	0.1	0.1	..
K.E. 672 (R 58)	..	1.7	..	..	..	..	..
Stainless steels							
18 Cr, 8 Ni, 0.1 C	2.1	1.9	..	..	..	..	..
3.5 Cr, 8.4 W, 0.35 V, 0.3 C	1.2	1.1	..	..	..	..	..
Carbon-chrome bearing steel (heat-treated)	1.4	..	..	..	..	..	..
Sintered tungsten carbide (R 76)	4.1	3.5	..	2.55	0.2	0.2	4.3
Tungsten	4.8	4.3	..	..	..	..	..
Stellite	4.0	3.7	..	..	..	..	..
Germanium single crystal	(31)	..	..	(28)	..	..	..
Titanium	(4.0)	..	..	..	..	..	..
Beryllium	(7)	..	..	..	..	..	..

*Rate in 0.001-in./min. relative to soda glass with 100 mesh boron carbide abrasive = 100. Tool, H-form, ½-in. sq. limbs 1/16-in. thick. Figures in brackets estimated.

to predict oversize quantitatively.

Variations of oversize with depth of cut and grit size of abrasive, under approximately optimum load conditions, are shown in Fig. 1. Oversize on radius is initially always a little greater than the lower limit of grit dimensions of the abrasive. Oversize at entry increases rapidly as the hole becomes deeper, to a value which corresponds fairly well to the upper limit of grit dimensions. Thereafter, increase is comparatively slow, being a function of both penetration and time, and relatively greater for smaller grit sizes. Oversize is a little greater in tungsten carbide than in glass for the same depth of cut, showing that ratio of lateral to longitudinal wear is greater in the former case.

Measurements show that drilled blind holes are always tapered toward the bottom in such a way that oversize at the bottom is only of the order of the smallest of abrasive grains present in the suspension.

Apart from abrasive, other factors contributing to oversize are those relating to precision of mechanical arrangements. Since cutting rates are so much greater when coarse abrasives are used, while good surface finish and close dimensional tolerances both demand fine grit size, drilling operations must be performed in several stages when very accurately-dimensioned holes are required. A hole is first drilled through using an undersized tool of dimensions which can be estimated from a knowledge of depth of cut and grain size of abrasive. Then, a second repassing or sizing operation is carried out, for which the tool will be cut only slightly undersize with a fine abrasive. Precise grit size will depend on surface finish required.

When great accuracy is required, or very deep holes to a reasonable tolerance, the hole can be drilled in three operations, the final one being done with a close-tolerance tool and a polishing grade of abrasive, such as 2000 mesh.

The order of dimensional accuracy obtainable in single-stage drilling operations is such that, even when using coarse (220 mesh) abrasive powder, dimensions of the cut can be predicted to within about ±0.002-in. if a tool is used which is considerably longer than hole depth. For two-stage drilling operations, dimensional accuracy achieved in glass and tungsten carbide, using 800 mesh repassing powder, can be better than ±0.0005-in.

Order of dimensional accuracy depends only on abrasive grit size and mechanical precision inherent in the mounting assembly, and is not restricted by any basic limitation imposed by the technique itself.

For cutting circular dies, for example, the vibration technique possesses a considerable advantage in speed over conventional methods. In such cases, both cutting speeds and circularity of the die hole can be improved by rotating the die at a slow constant rate during drilling.

Surface Finish: Measurements have been made of the quality of surface finish obtained on bottoms and sides of roughed and repassed holes in glass and tungsten carbide. These measurements were carried out with the aid of a Talysurf roughness tester which plots a trace of surface irregularities

Table 2—Comparative Cutting Speeds in Various Brittle Materials*

Abrasive→	Boron Carbide			Silicon Carbide
Material	100 mesh	200 mesh	400 mesh	100 mesh
Soda glass	100	90	77	85
Hysil	73	66	54	..
Borosilicate glass	86	..	..	..
Ferroxcube IIIC	37	..	..	34
Ferroxdure (demagnetized)	(32)	..	..	..
Quartz crystal	(57)	..	..	..
Fused alumina	19	..	..	..
Synthetic sapphire	19	..	..	..
Synthetic ruby	18	..	..	..
Flint Stone	(72)	..	..	..
Barium-titanate ceramic	110	..	..	109
Ceramic 507	(38)	..	..	35
Carnet	(58)	..	..	..
Felspar	(40)	..	..	..
Spinel	(48)	..	..	..
Slate	67	..	..	..
Mycalex	(240)	..	..	(200)

*Rate in 0.001-in./min. relative to soda glass with 100 mesh boron carbide abrasive= 100. Tool, H-form, ½-in. sq. limbs 1/16-in. thick. Figures in brackets estimated.

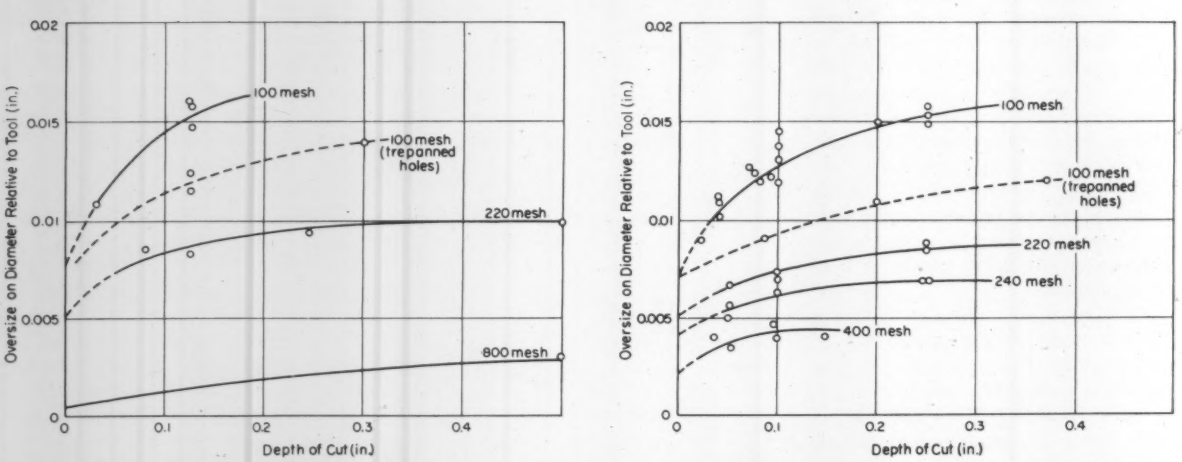

Fig. 1—Variations of oversize with depth of cut and abrasive grit size under optimum load conditions. Left, in tungsten carbide. Right, in soda glass. Abrasive in both cases was boron carbide.

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and records a center-line average figure for roughness height over the final 0.3-in. of surface examined. The following general conclusions can be drawn from all measurements recorded.

Quality of surface finish is closely related to abrasive grit size as shown in Fig. 2. For coarse abrasives, peak-to-peak irregularities sometimes amount to as much as 0.001-in. while for fine powders

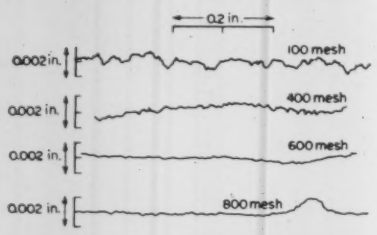


Fig. 2—Quality of surface finish related to abrasive grit size. Surface traces over bottoms of blind holes in glass bored with boron carbide abrasives were made under optimum drilling condition.

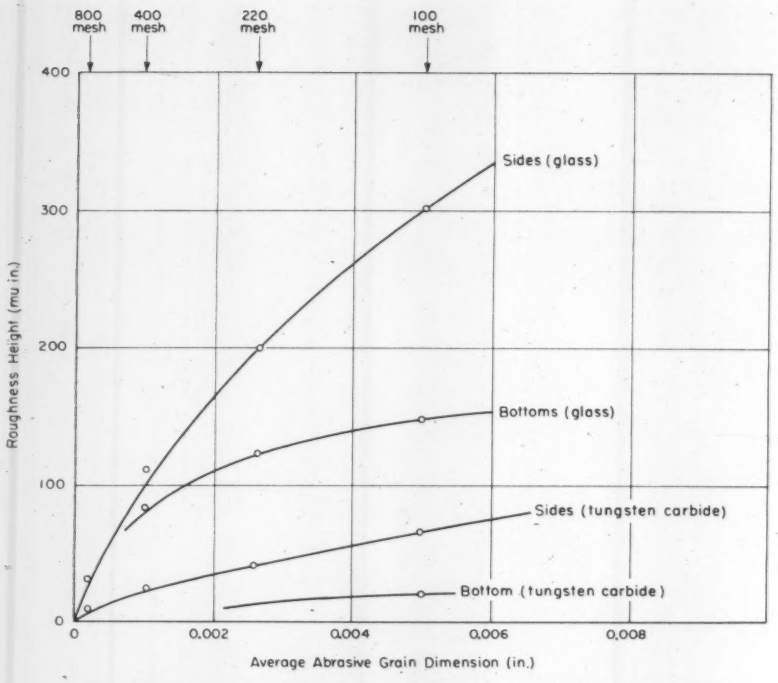


Fig. 3—Surface roughness height as a function of abrasive size for holes in glass and tungsten carbide. For same operating conditions, roughness heights in glass and tungsten carbide are in the ratio of 7 to 1, although cutting speeds are 24 to 1.

they are not more than 0.0001-in.

Quality of surface finish appears to be independent of static loading conditions. It might be expected that roughness height should increase approximately linearly with applied load in the same way as cutting speed. However, there is a compensating effect associated with abrasive flow. Increasing load results in a reduction in size of abrasive grains which can reach the tool face. Consequently, when coarse abrasives are used, roughness height on the sides of blind holes is greater than at the bottoms.

The roughness height does depend somewhat on oscillatory amplitude of the tool. It increases slowly with amplitude under optimum drilling conditions.

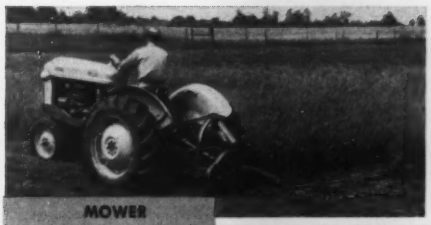
Fig. 3 shows a plot of measured surface roughness height as a function of abrasive grit size in glass and tungsten carbide. In piercing operations, roughness height at the sides is of the same order as that obtained at the bottom except when the coarsest abrasives are used. In repassing operations, for all practical purposes, surface finish can be taken to be dependent only on grit size of abrasive and independent of oscillatory amplitude and static load. Under the same operating conditions, ratio of roughness heights in glass and tungsten carbide (bottoms of holes) is approximately 7 to 1, although cutting speed ratio is about 24 to 1.

Advantages: Tools based on ultrasonic vibrators have rendered possible new types of machining operations, jobs which had not previously been attempted on account of extreme difficulty or tediousness.

Briefly, the ultrasonic machining technique is characterized by rapid cutting rates combined with comparative ease with which accuracy and extremely good surface finishes can be achieved. No heat is generated in the work and consequently no changes are introduced in the physical structure of the material. Equipment is safe to handle and requires skilled labor only in making and setting of actual tools. The technique is applicable to all brittle materials and is not limited by any other physical property of the substance. Extreme hardness of work material does not constitute a limitation to its machinability, but it is, of course, necessary to chose an abrasive which is as hard or, preferably, appreciably harder.

For forming irregular-shaped holes and depressions, patternmaking and multiple cutting in brittle nonconducting materials, the vibration technique virtually has no competitor. When applied to conducting materials, the ultrasonic method is in competition with new electroerosion processes. The chief competitor to vibration machining techniques is the electrosparking process. Although this method is capable of extremely high cutting speeds, it is not possible to rapidly achieve a good quality finish. To obtain even a reasonably good finish it is necessary to perform machining in several successive operations, of which the final one may be extremely lengthy.

From "Ultrasonic Machining" in Phillips Technical Review, *Vol. 18, No. 22, courtesy of Phillips Electronics Inc.*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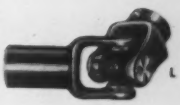
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ROCKWELL SPRING AND AXLE COMPANY

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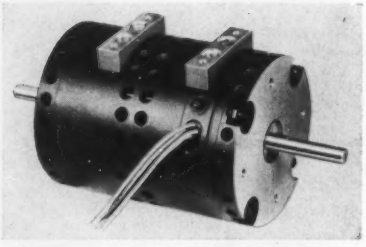
UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Circle 458 on page 19

Application, control and maintenance of

High-Frequency Motors

By VERNON C. GECKLER
General Motors Corp.
Bristol, Conn.



A typical 400-cycle ac motor. Motor has double-end shaft, delivers 1/3 hp, weighs 4½ lb, and operates at 5600 rpm on three-phase, 400-cycle, 200-v ac. (Courtesy U.S. Electrical Motors Inc.)

HIGH-FREQUENCY motors are approximately one-fourth the size and weight of standard 60-cycle motors. The three-phase motor has been generally adopted for high frequency basically because it is the simplest and most trouble-free type. High-frequency motors can be wound for any phase, governed only by physical limitation in motor design. They are readily available for many applications and may be obtained as a complete motor ready for installation, or as separate stators and rotors for assembly in special enclosures for particular applications.

General NEMA Standards for high-frequency motors, generators and frequency converters are shown in Table 1.

Controls: Standard 60-cycle control devices, i.e., relays, line starters, disconnect switches and pushbuttons are used for controlling high-frequency motors. However, it is necessary in applications of fused disconnect switches and circuit breakers to apply a derating factor to prevent excessive heating. For enclosed installations, units should be derated an additional 15 per cent.

Interrupting capacity of circuit breakers and disconnect switches is not affected by high frequencies except in certain instances. Before application is made, manufacturers' recommendations should be obtained.

Lubrication: Motor-bearing lubrication is important where high speeds are involved, due to increased friction and heat in bearings. Shafts, at speeds up to 6000 rpm, can be lubricated satisfactorily with a paraffin oil with a 100-sec rating using drip oilers, or with grease lubricant. For speeds higher than 6000 rpm, a mist lubrication system using medium oil with a 240-sec rating is required for good bearing life. Compressed air must be thoroughly filtered before oil is introduced, and a pressure regulator provided for correct quantity of mist. A pressure switch, which prevents motor starting before the mist lubrication system is in operation, will prevent burning out motor bearings.

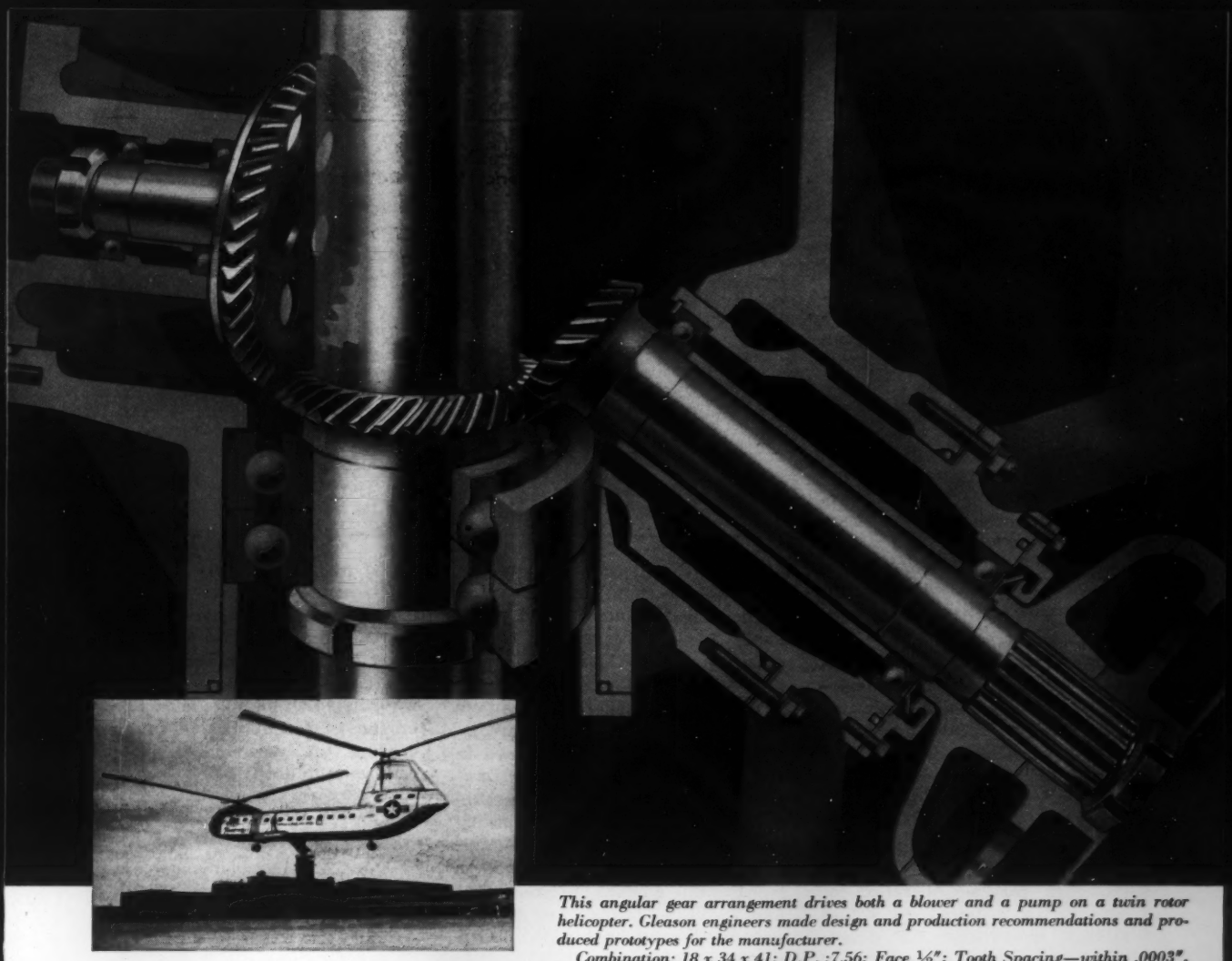
Failure of a motor bearing usually causes the motor to slow down resulting in excessive current being drawn by the stator winding. This, in turn, builds up sufficient heat in the rotor to melt the end connection of the squirrel-cage winding.

Spindle-Motor Cooling: Spindle-motors are typical of applications involving high-frequency power. Dependent upon application and speed, methods of adequate cooling of the spindle-motor fall into three classes:

1. Open-type motors for atmospheres free of airborne contamination.
2. Totally enclosed motors for contaminated atmospheres.
3. Liquid-cooled motors for speeds over 24,000 rpm.

As frequency is increased to obtain these higher speeds, motor losses automatically increase, converting a greater amount of power into heat. This heat cannot be dissipated by air cooling due to the physical inability to pass sufficient air through the motor. Consequently, liquid cooling is the only practical method of controlling motor heat rise.

Satisfactory liquid cooling may be obtained by passing a quantity of filtered compound or oil through the motor. Water-soluble compounds are most satisfactory, due to rapid heat transfer. Oils tend to have slower heat transfer properties depending upon viscosity.



This angular gear arrangement drives both a blower and a pump on a twin rotor helicopter. Gleason engineers made design and production recommendations and produced prototypes for the manufacturer.
Combination: 18 x 34 x 41; D.P. :7.56; Face ½"; Tooth Spacing—within .0003".

You can solve your angular power transmission problems, too!

The designers of this gear unit achieve greater flexibility within a limited amount of space by placing the drive shafts at an angle and using one source of power to drive two auxiliary units.

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Our engineers are ready to help you work out applications for bevel and hypoid gears—just as they helped the helicopter manufacturer with the design illustrated above.

We recommended the proper gear sizes and reviewed the mountings and lubrication for the drive. Then we produced and tested prototypes of the unit.

If you would like to discuss an application with one of our representatives, please write. You will also find these Gleason Technical Handbooks helpful: 20° Straight Bevel Gear System; Spiral Bevel Gear System; ZEROL Bevel System.

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Circle 459 on page 19

Maintenance: Maintenance requirements for high-frequency controls, motors, generators and converters are not much different than for 60-cycle equipment. In dismantling and overhauling a high-frequency motor, the rotor should be both statically and dynamically balanced before assembly. Special care should be given to spindle bearings during assembly since cleanliness is important to bearing life.

In regard to electrical controls, a loose or worn contact in a motor starter, disconnect switch or relay causes rapid heating and eventual failure of equipment. Adequate preventive maintenance programs should be established to minimize motor down-time.

Motor Generators: Motor-generator sets are the most commonly used source of high-frequency power. They are made to order in standard generator sizes for voltages and frequencies specified. V-belt-connected motors and generators are most commonly used due to flexibility in changing speeds for different frequency requirements. If parallel operation of generators is required to obtain flexibility in capacity, a direct-coupled motor and generator are required and may be paralleled in the same manner as 60-cycle equipment.

Converters: Frequency converters are available to change from 60-cycle to a higher frequency. They have the advantage of being self-contained with appearance of a single motor or generator, take up less floor area, and are quite maintenance-free. Converters are desirable for fixed-load applications. However, voltage regulation on converter sets is approximately 15 per cent and is obtained by series capacitors in the converter winding circuit. In this equipment, motor and converter windings are located in one frame on the same stator laminations. If a converter is to be applied to varying load conditions, it is possible to experience self-excitation which causes motors to slow down, and both voltage and frequency to become unstable. The converter also has the disadvantage of not being able to change speeds or frequencies and cannot be used where flexibility in frequencies is required.

Table 1—High-Frequency Motor Rating Standards in Volts

	Frequency (cycles)*											
Band	60	120	180	240	360	540	720	1080	1440	2160	2880	4320
1	220	440	...	...	...	...	...	...	...	...	...	...
2	...	220	330	440	...	...	...	...	...	...	...	...
3	...	147	220	293	440	...	...	...	...	...	...	...
4	...	...	110	147	220	330	440	...	...	...	...	...
5	...	...	...	...	110	165	220	330	...	...	...	...
6	...	...	...	...	...	...	...	165	220	330	...	...
7	...	...	...	...	...	...	...	...	110	165	220	...
8	...	...	...	...	...	...	...	...	...	110	147	220

*At frequencies other than listed, voltage is in direct proportion to frequency.

Voltages: Generator voltage may be used direct in its distribution, or it may be transformed in the same manner as 60-cycle power. However, transformation requires special high - frequency transformers, usually dry - type auto transformers. They add a substantial amount of reactance and resultant voltage loss and, in general, should be avoided. Corrective capacitance can be applied in the form of high-frequency capacitors in such cases.

Value of voltage generated, distributed and used by the motor is not of importance insofar as performance is concerned as long as this value falls within practical application and safe operating conditions. Referring to Table 1, voltage of the generator is in direct proportion to the frequency controlled by generator speed. For example, a motor operating on 120 cycles at 147 v can also be used on 360 cycles at 440 v at the same efficiency.

Standard 60-cycle measuring instruments can usually be used to obtain values of voltage, current, kilowatts and power factor.

Line Losses: General distribution of high-frequency power is considerably different than that of 60-cycle, due to increased reactance loss. Generally, reactance increase above 60-cycle is directly proportional to frequency increase. Also, as frequency increases, skin effect of the cable increases, wherein current tends to travel more in the outer layers than in the center of the conductor. There are three ways in which high-frequency power can be distributed without exceeding the recommended 3 per cent voltage drop:

1. Where voltage drop is excessive with three conductors, a parallel three-conductor line should be run connected at both ends. It must be assumed that these cables are of the same length and size which, in effect, is putting impedances in parallel.
2. Line can be a three-conductor cable within one enclosure which places all conductors in as close proximity to each other as is possible, and further reduces reactance of the line.
3. Distribution may be accomplished with concentric cables having central and outer conductors. Three such conductors, properly phased, are very effective in reduction of reactance.

It is advisable with frequencies above 1000 cycles to run distribution lines in either nonmetallic conduits or in the open, and to apply capacitors at the motor to correct line losses due to low power factor. At 1600 cycles, this is a definite requirement as the power factor drops so low that the motor will not run.

From a paper entitled "Industrial Application of High-Frequency Power" presented at the AIEE Summer General Meeting in Montreal, Que., June, 1957.

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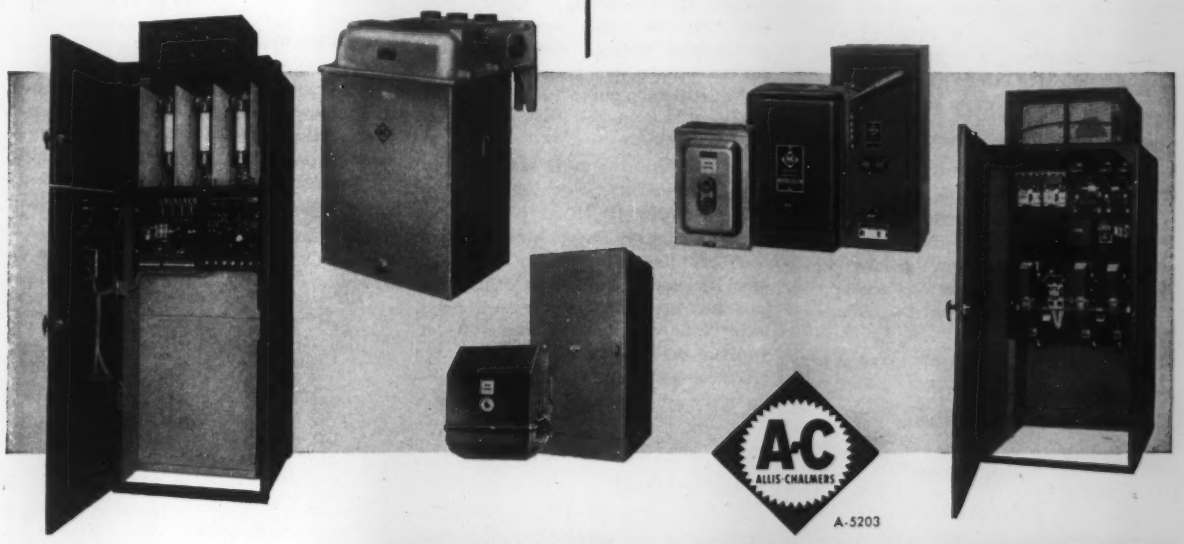


A-5203

ALLIS-CHALMERS

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Blind Rivets

Complete dimensional data and specifications are given in brochure 8-388 for line of CKL blind rivets in both brazier head and countersunk head types, as well as oversize diameter countersunk head types. Line drawings show step-by-step driving cycle. Minimum blind side clearance, driving procedure and inspection are discussed. 16 pages. Huck Mfg. Co.

Circle 581 on page 19

Telephone Type Relays

Type 8 multiple-contact telephone type relays are subject of illustrated engineering bulletin. Details are given on stock and special contact relays in enclosed and hermetically sealed models. 4 pages. Phillips Control Corp.

Circle 582 on page 19

Deep-Drawn Parts

Pictured in illustrated bulletin No. 80 are typical precision metal stampings and deep-drawn parts which were produced to users' specifications. Sizes range from micro-miniature electron tube parts to large TV bezel. Facilities of company for engineering and producing stampings are detailed. 4 pages. Johnson & Hoffman Mfg. Corp.

Circle 583 on page 19

Foam Plastic

"Imagineering for Profit" is title of illustrated idea book of products that can be made with Dylite expandable polystyrene. Uses as building material, insulation, decoration, floats and other applications are covered. 12 pages. Koppers Co., Chemical Div.

Circle 584 on page 19

Electrical Insulation

"Westinghouse Insulating Materials" is title of illustrated booklet B-7206. It discusses types, applications and characteristics of class A shellac and varnish coated papers, varnished fabrics, slot cell insulation, and organic varnished glass. Also covered are class B and class H insulations. Properties of insulating varnishes, enamels, primers, finishes, and compounds are detailed. 8 pages. Westinghouse Electric Corp.

Circle 585 on page 19

Tracing Paper

Visi-Vel resin-transparentized tracing paper is reported to combine excellent translucency with strength and workability in illustrated folder. Included is special offer of a 36-in. wide, 5-yd long roll of this tracing paper for $1. 4 pages. Charles Bruning Co.

Circle 586 on page 19

Panel Instruments

Photos, outline drawings, theory of operation, descriptions, and specifications of complete line of panel-mounting instruments are contained in illustrated catalog and designers' guide. Miniature and electronic types are included in line. 36 pages. Trio Laboratories, Inc.

Circle 587 on page 19

Decimal-Binary Tables

Series of tables to simplify conversion from decimal to binary numbers, or vice versa, are included in pocket-size folder. Tables are useful for those working with coding systems that make use of binary numbers. 6 pages. Barnes Engineering Co.

Circle 588 on page 19

Hose Couplings

Le-Hi heavy duty, high pressure hose couplings for use on air, steam, gas, hydraulic, fluid, and other services are described in illustrated bulletin 115. Types are available for applications in construction, mining, contacting, oil refining, and general industry. 8 pages. Hose Accessories Co., Le-Hi Div.

Circle 589 on page 19

Stainless Steel

Bulletin G-22 is entitled "Stainless Steel Data." Characteristics of three major types of stainless steels are outlined, together with their advantages in various types of applications. Properties of these steels at elevated temperatures are charted. Design information as related to manufacture of Allen Hex-Socket screws is presented. 16 pages. Allen Mfg. Co.

Circle 590 on page 19

Galvanometric Recorder

Three illustrated bulletins, R-501 and supplements, deal with the recti/riter rectilinear galvanometric recorder for fast, accurate data reduction. System inscribes a signal in its true shape on a rectilinear chart in a form that can be measured with a ruler. 10 pages. Houston Technical Laboratories.

Circle 591 on page 19

Gearing

Typical shafts, spiral bevels, ratchets, spurs, worms, helicals, spring loaded gears, racks, cams, and other gearing products for fractional horsepower service are shown in illustrated folder. Facilities of company for producing custom gears are pictured. 6 pages. Gear Specialties, Inc.

Circle 592 on page 19

Electrical Steel

Detailed information and technical graphs give complete physical, mechanical, and magnetic property data on Allegheny Ludlum electrical steel 4750. Also covered are machining and fabrication of this material. 20 pages. Allegheny Ludlum Steel Corp.

Circle 593 on page 19

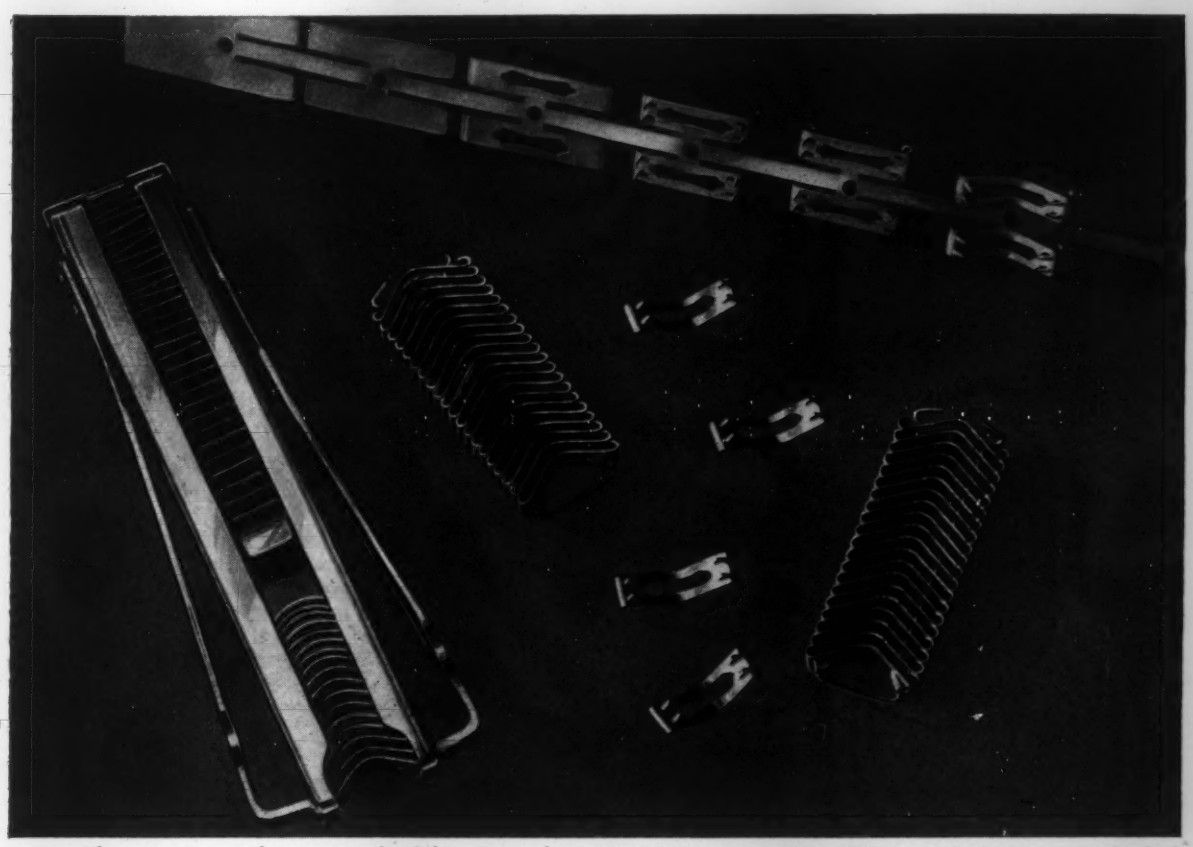
Air-Operated Valves

Air-operated Saunders valves which feature close-coupled design, on-off and throttling control, and availability in sizes and constructions for practically every need are subject of bulletin HB-6. 8 pages. Conoflow Corp.

Circle 594 on page 19

Ceramic Magnets

Illustrated bulletin RC-11A is descriptive of Ceramagnets. These high coercive force permanent mag-



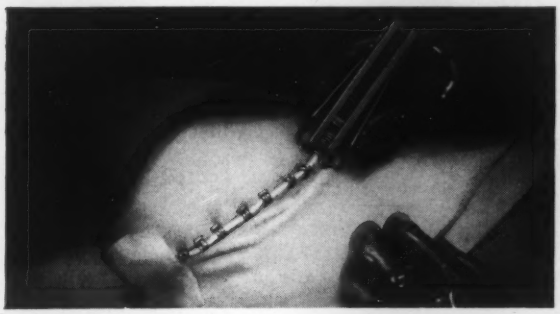
Above: The various steps in forming Autoclips® from Anaconda 18% Nickel Silver strip, .637" wide by .013" thick. Below are individual Autoclips and those mounted in wire holders ready for insertion in Autoclip Applier, at left. Exclusive wholesale distributor for Autoclip is Clay-Adams, Inc., New Yo:k City. ***Below, left:*** Autoclips being used to attach skin towel to edges of incision.

Anaconda Technical Service helped in

Selecting the exact Nickel Silver strip for this surgical clip

THE PROBLEM: The Technical Oil Tool Corporation, Los Angeles, developed Autoclip, an automatic magazine-type clip and applier to close wounds or incisions faster and easier. Selecting the right metal for the clip was the problem. A certain amount of tension was required to hold the wound edges together during healing, with the least amount of damage to tissues. In addition, the clip had to open easily for painless removal. The metal should be easy to form, and retain sharp, die-cut edges.

THE SOLUTION: After several unsuccessful attempts with various metals, sample clips of the required gage were made of Nickel Silver. These silvery white copper-alloys have excellent resistance to corrosion in service or in storage and have been time-tested for surgical instruments and equipment. Technical specialists of The American Brass Company suggested Nickel Silver, 18%-719—one of four standard Anaconda Nickel Silver Alloys—as the one best suited to meet all the requirements including tension, formability, clean edges and sharp points.



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Circle 461 on page 19

nets are molded from low-cost ceramic powders to exacting mechanical, electrical, and other specifications. Ten graphs plot magnetic characteristics of importance to designers. 12 pages. Stackpole Carbon Co.

Cirlce 595 on page 19

Gearing

Spur, bevel, miter, herringbone, helical, internal, and worm gears can be produced to users' specifications by facilities of this company which are described in illustrated bulletin No. 155. Company is also equipped to produce generated tooth racks and cut sprockets as well as to perform precision surface finishing. 8 pages. Industrial Gear Mfg. Co.

Circle 596 on page 19

Seals

Lathe cut dynamic and static seals are available in sizes ranging from ½ in. minimum ID to 25 in. maximum OD in minimum thicknesses of 1/32 in. They are made of various polymers suited for practically any service need. Full information is given in illustrated bulletin. 4 pages. Western Felt Works, Acadia Synthetic Products Div.

Circle 597 on page 19

Shaft-Mounted Drives

Selection tables for Falk shaft-mounted drives in ½ to 40-hp ratings in class I, ½ to 25-hp ratings in class II, and ½ to 20-hp ratings in class III are contained in supplement 7101. Wide range of ratios is available in these compact gear speed reduction units. 4 pages. Falk Corp.

Circle 598 on page 19

Formed Tubes

Potential uses of fabricated tubes and tubular assemblies are subject of illustrated bulletin "Take a Look at Formed Tubes." This plant is equipped to bend, weld, flange, swage, flare, pierce, flatten, and rivet tubes into any required conformation. Facilities of company are described. 16 pages. Formed Tubes, Inc.

Circle 599 on page 19

Small Motors

Both reducer and nonreducer types are included in the 265 stock small motors listed in bulletin S. Horsepower ratings of standard motors range from 1/7 to 1/1500. Reducer motors, with speeds ranging from 833 to 0.7 rpm, have torques of 12.8 oz-in. to 219 lb-in. 12 pages. Bodine Electric Co.

Circle 600 on page 19

Roller Chains & Sprockets

Complete selection and application data on stock roller chains and sprockets with finish-bored and taper-bushed hubs are presented in engineering catalog No. 757. Tables contain dimension, price and engineering information on complete lines. 72 pages. Diamond Chain Co.

Circle 601 on page 19

Silicone Rubber

The physical properties of Silastic silicone rubber which adapt it for use in a variety of mechanical parts are discussed in bulletin 9-106. Material is resistant to heat, cold, weathering, ozone, moisture, oils, and chemicals. Graphs and tables amplify the text. 6 pages. Dow Corning Corp.

Circle 602 on page 19

Drafting Machines

Details of full line of drafting machines, drafting tables and desks, accessories, and drafting scales are contained in comprehensive catalog. Price list K-205 gives latest price data on this West-German-made equipment. 16 pages. Unitech Corp.

Circle 603 on page 19

Machinery Steel

Properties of Elastuf Penn machinery steel which adapt it for a wide range of machined parts are covered in illustrated bulletin. Tables and charts supplement the text in presenting the analysis, mechanical properties, heat treatment and machinability of this material. 8 pages. Horace T. Potts Co.

Circle 604 on page 19

Selector Switches

Designed for use on thermocouple or resistance bulb circuits, a complete line of key or push-button type selector switches and housings is shown in catalog section 24-1. Available switching arrangements are diagrammed. 4 pages. Thermo Electric Co.

Circle 605 on page 19

Heavy Duty Footswitches

Specifications on each of 40 models of Hercules heavy-duty footswitches are presented in bulletin. General purpose, water-tight enclosure, explosionproof, and high direct-current rated switches, in maintained and momentary contact types, are covered. 4 pages. Linemaster Switch Corp.

Circle 606 on page 19

Air Conditioning Fittings

Over 600 items relative to refrigeration and air conditioning are listed in catalog R-657. In addition to charging lines, a hermetic port valve, and refrigerant dispensing kits, catalog shows flare fittings, strainers and driers, capillary tube, tube working tools and brass pipe fittings. 20 pages. Madden Brass Products Co.

Circle 607 on page 19

Voltage Regulators

Covering both glass and metal corona type voltage regulators, bulletin 3003-7 gives performance curves and complete specifications and dimensions. Schematics for five applications are featured. 4 pages. Victoreen Instrument Co.

Circle 608 on page 19

Step-Down Transformers

Step-down transformers specified in bulletin SD 311 can be mounted on all types of industrial machines and connected to 230 v power circuit. Output provided is 115 v for lighting, operating machine accessories, and other maintenance work around the machines. 4 pages. Acme Electric Corp.

Circle 609 on page 19

Four-Cycle Engines

Kohler short-stroke four-cycle air-cooled engines described and specified in form EN 269 include 3.6, 6.6, 12.5, and 26.8 hp units. Engines feature quick starting in all kinds of weather. 4 pages. Kohler Co.

Circle 610 on page 19

Breadboard Parts

All parts necessary for easy assembly of complicated gear trains and servomechanisms are described in catalog 575. Typical schematics representative of basic synchro transmitter and receiver systems, and a mechanical resolver system are included in this control system guide. 24 pages. Helipot Corp.

Circle 611 on page 19

Aircraft Hose & Accessories

Information on company's standard aircraft line of hose, fittings, elbow assemblies, and self-sealing

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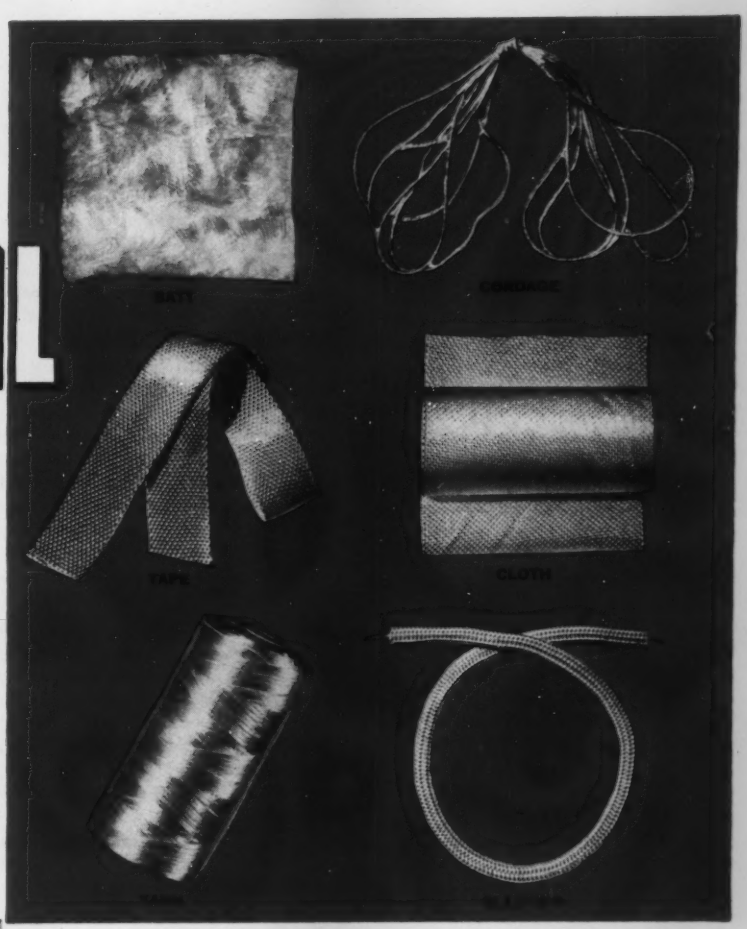

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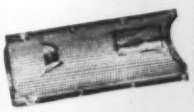

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couplings is provided in condensed bulletin 240. Data cover low, medium, and high pressure hose assemblies, as well as the new 666 Teflon hose with Super Gem fittings. 12 pages. Aeroquip Corp.

Circle 612 on page 19

Torque Converters

Engineering features which make National torque converters suitable for excavators, cranes, and shovels are pointed up in data sheet 101. Engines to which torque converters can be applied are listed. 4 pages. National Supply Co., Industrial Products Div.

Circle 613 on page 19

Brazing Alloys

Engineering Data Sheet No. 16 tabulates specifications for the full range of Nicrobraz high temperature brazing alloys. Features and recommended applications for each alloy are included. 2 pages. Wall Colmonoy Corp., Stainless Processing Div.

Circle 614 on page 19

Offset Duplicators

Form 48 illustrates and explains how the Signal Corps uses XeroX model 1218 copying equipment and offset duplicators to speed drawings and specifications to potential suppliers. Specifications are listed. 4 pages. Haloid Co.

Circle 615 on page 19

Gears & Speed Reducers

Power transmission data compiled in 1957 handbook is revised to meet modern engineering standards. Charts, tables and formulas will help designers select the right gears and speed reducers for the job. Dimensions on standard spur, bevel, spiral, helical, and worm gears are tabulated. 186 pages. Ohio Gear Co.

Circle 616 on page 19

Castings Literature

Contents of 15 Society publications dealing with selection, purchasing, design, and fabrication of gray iron castings are described in folder entitled "Technical Literature on Castings." 8 pages. Gray Iron Founders' Society, Inc.

Circle 617 on page 19

Clutches

Over-running, single revolution, thermostatic controlled, pin actuated, cone actuated, reversing, and bi-directional no-back Precisionspring clutches are described in bulletin PSC-100. Supplementary bulletins SB-20 and OB-10 provide details on over-running sleeve bearing and ball bearing types, respectively. 8 pages in all. Curtiss-Wright Corp., Marquette Div.

Circle 618 on page 19

Potentiometers & Bridges

Line of small self-balancing electronic potentiometers and bridges made in both recording and indicating versions are described in bulletin P1271. Instruments are available in alternating-current bridge, direct current-potentiometer, and differential transformer balance types. 4 pages. Bristol Co.

Circle 619 on page 19

Self-Locking Nuts

Microsize Flexloc self-locking nuts and clinch nuts described in form 2249 range in size from No. 0 to 4 and are offered in steel, stainless steel, brass, and aluminum. They have an integral knurled shank for mounting in thin-section materials. 4 pages. Standard Pressed Steel Co.

Circle 620 on page 19

Automatic Lubrication

Bulletin entitled "The A.B.C. of Modern Lubrication" describes the three basic elements of automatic lubrication—lubricators, distribution systems and Meter-Units. Eight types of automatic lubricators are shown. 4 pages. Bijur Lubricating Corp.

Circle 621 on page 19

Miniature Potentiometer

Specifications, resistance values, dimensions, and prices are given on type AS miniature potentiometers in bulletin 149. These dust-tight, splashproof, and fungus-resistant molded composition units are intended for small or miniature apparatus in domestic and military use. 2 pages. Ohmite Mfg. Co.

Circle 622 on page 19

AC Motor Starters

Line of motor starters and contactors described in bulletin 14B8615 includes ratings from 50 to 400 hp. Units can be applied to practically all types of drives including pumps, crushers, blowers, fans, screens, and furnace controls. Contactors incorporate arc interruption which eliminates need for conventional blowout coils. 12 pages. Allis-Chalmers Mfg. Co.

Circle 623 on page 19

Magnesium Specifications

"Magnesium Specification Digest" lists all magnesium product and process specifications issued by Government procurement agencies and technical societies. Brief digest and interpretation of each specification as related to Dow products is included. Request bulletin 141-138. 22 pages. Dow Chemical Co.

Circle 624 on page 19

Protective Metal Coatings

Zincilate corrosion and abrasion-resistant protective coatings which can be applied to iron, steel, or aluminum by spray, brush, flow, or dip methods are described as to characteristics and properties in data sheet. 2 pages. Industrial Metal Protectives, Inc.

Circle 625 on page 19

Electric Clutch

Model GS electro-magnetic disk clutch for use in machine tools, and paper and textile machinery is subject of descriptive bulletin 503. Clutch is offered in slip torque values from 9 to 540 lb-ft. Bulletin points up features. 4 pages. Stearns Electric Corp.

Circle 626 on page 19

Self-Locking Bolts

Positive locking, seated or not, is achieved with self-locking Nylok bolts which feature the permanent nylon insert in the bolt body. Function of this type bolt is explained in form 792. Characteristics of nylon are also discussed. 4 pages. Republic Steel Corp., Bolt & Chain Div.

Circle 627 on page 19

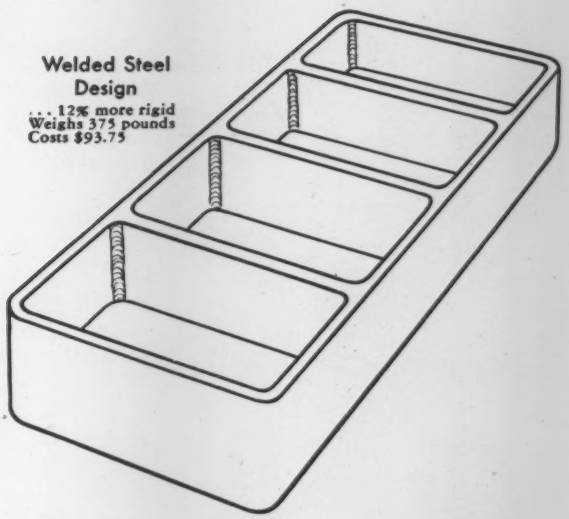
Motor Driven Cycle Timer

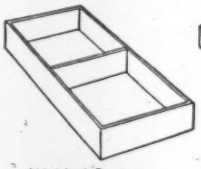
Application and operation data are presented in bulletin PB-571 on the type 571 motor driven cycle timer. Data cover time ranges, ratings, material, and construction specifications. Several nonstandard arrangements for special uses are suggested. Cramer Controls Corp.

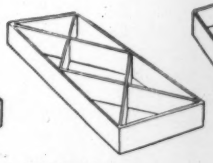
Circle 628 on page 19

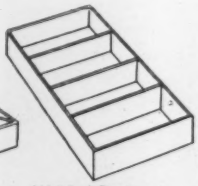
Electric Motors

Brochure 194 descriptively covers the complete Sterling line of standard electric motors. It illustrates several motor applications and provides pertinent selection informa-

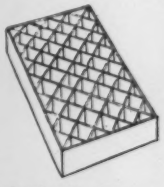


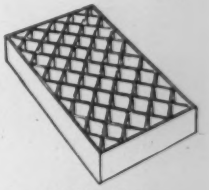

Welded Design
. . . 30% more rigid
Weighs 575 pounds
Costs $143.00


Welded Design
. . . 76% more rigid
Weighs 525 pounds
Costs $132.00


Welded Design
. . . 10% more rigid
Weighs 375 pounds
Costs $93.75

Welded Design
. . . 33% more rigid
Weighs 355 pounds
Costs $89.00


Welded Design
. . . 80% more rigid
Weighs 295 pounds
Costs $74.00


Welded Design
. . . 80% more rigid
Weighs 295 pounds
Costs $74.00

How to Increase Rigidity of Machine Bases

. . . while cutting weight and cost

Machine base (A) made from gray iron used 1⅛" thick sections, weighs 890 pounds.

Machine base (B) designed for welded steel needs only 7/16" sections, yet is 1.12 times more rigid. Since smaller sections are used, base (B) requires only 375 pounds of material. Based on the fact that steel costs less than iron, and less steel is used—material savings are $51.50.

The smaller drawings show variations of this machine base with rigidity and price as compared to the cast design.

By taking advantage of the stronger, more rigid properties of steel, additional savings in material cost can be made as shown to further reduce over-all costs of production.

Designers!

Ask your Lincoln representative how you apply these potential savings to your designs. Available also: New Procedure Handbook of Arc Welding Design & Practice at slight cost; Machine Design Sheets and Design Courses at Lincoln Electric main plant. Write

THE LINCOLN ELECTRIC COMPANY

Dept. 1124 • Cleveland 17, Ohio

The World's Largest Manufacturer of Arc Welding Equipment

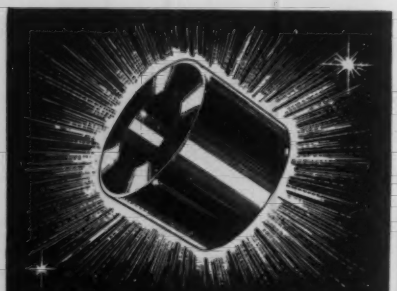
When steel is 3 times stronger

Has 2½ times the rigidity

Yet costs a third as much

WHY use anything but welded designs?

Circle 463 on page 19



GET THE FACTS ON

GRAPHALLOY

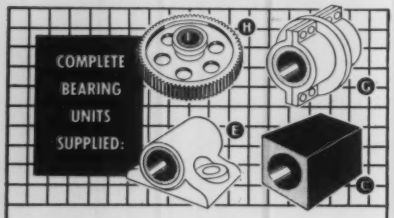
LONG WEARING
LOW FRICTION

UNIQUE (OIL-FREE)

SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.) OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

USE OUR 40 YEARS OF DESIGN EXPERIENCE!

GRAPHITE METALLIZING CORPORATION

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☐ Please send data on Graphalloy Oil-Free BUSHINGS.
☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE

COMPANY

STREET

CITY ZONE STATE

Circle 464 on page 19

Helpful Literature

tion. Various dripproof, totally enclosed fan cooled, and vertical flange-mounted units are offered. 12 pages. Sterling Electric Motors, Inc.

Circle 629 on page 19

Phenolics

Physical properties of Durez phenolic molding compounds are found in illustrated booklet. Data on general purpose, medium and high impact, nitrile-rubber bearing, electrical and heat resisting, nonbleeding, and chemical and moisture resisting materials are given. 16 pages. Hooker Electrochemical Co., Durez Plastics Div.

Circle 630 on page 19

Flat-Top Roller Chain

Ny-Steel flat-top conveyor chain has a smooth surface for conveying cans, bottles, packages, and small parts. Top plate of nylon is fastened to carbon or stainless steel roller chain. Specifications are given in illustrated folder 2492. 4 pages. Link-Belt Co.

Circle 631 on page 19

Reversible Motors

Type TYAZ-CE reversible geared motors for use in servomechanisms, voltage regulators, and combustion and industrial controls are described in illustrated catalog GR2. Voltages range from 6 to 220 v ac and starting torques to 50 lb-in. 4 pages. Barber-Colman Co., Small Motors Div.

Circle 632 on page 19

Binding Posts

Connections can be made to 5-way binding posts in five different ways, all described in illustrated bulletin BP656. Posts are offered in five colors. Available sizes, design features, and prices are given. 4 pages. Superior Electric Co.

Circle 633 on page 19

Blueprint File

Inter-Master blueprint files that interlock and intermember with existing units are subject of illustrated bulletin 604. Three and five-drawer units are offered, along with bases, dust covers, and caps. 2 pages. Stacor Equipment Co.

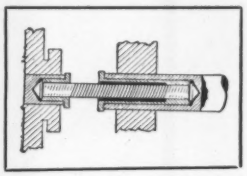
Circle 634 on page 19

Titanium Facts

Titanium's advantages; physical, mechanical, and corrosion properties; metallurgy; machining; and

(Advertisement)

FLEXIBLE SHAFT COUPLING for Industrial Design



Coupling is used for the transmission of power or control of movement between parts located close together in a piece of equipment. It is not a separate type of flexible shaft but rather an added application of flexible shafting.

The coupling can be composed of either power drive or remote control flexible shafting although the latter is generally used due to the added advantage of its ability to rotate both clockwise and counter clockwise. Generally used between two units which are but a few inches apart, coupling may transmit power between any two parts regardless of their relative positions.

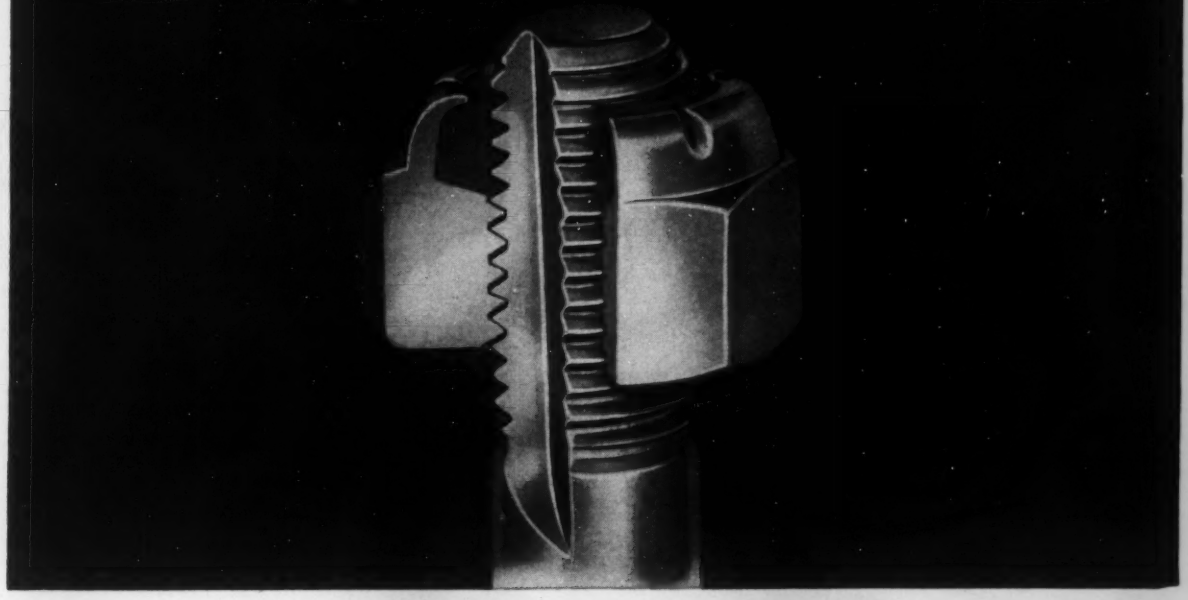
For example, the diagram above shows an advantage in using small lengths of flexible shafting in a coupling application. Although the drive end and the driven end are not exactly in line, the coupling compensates for the difference in alignment between the two.

Many manufacturers use flexible shaft coupling even where parts may be connected by solid shafts because of the savings realized in the initial and the maintenance costs as well as in time and labor.

For complete information on how flexible shaft couplings may help improve your product design, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 465 on page 19

The nylon collared Elastic Stop nut never damages bolt threads!



The nylon locking insert * will not seize threads, gall or remove plating

The red nylon locking collar is an integral part of an Elastic Stop nut. Undersize in diameter in relation to standard bolt tolerances, this insert grips the entering bolt threads with strong, smooth nylon fingers that dampen impact loads and resist turning under the most severe conditions of vibration or shock. The perfect fit between bolt threads and the locking collar also serves to seal off internal bolt and nut threads and to protect them against corrosion. Furthermore the nylon insert is impervious to gasolines, oils, salt atmospheres, cleaning compounds and common acids. The remarkable wear resistance of nylon plus its elastic recovery makes Elastic Stop nuts reusable through more than a hundred on and off cycles.

Because an Elastic Stop nut is a one-piece unit it is less expensive to install than castellated nuts and cotter pins, or double nuts. Equally important, it is a *stop* nut that *locks at any position on the bolt* without requiring secondary "safety" devices; it is simple to adjust precisely—it is easily wrenched off or readjusted. Elastic Stop nuts have been used by American industry since 1930 to solve the toughest applications on railroad, automotive, earth moving and farm equipment, as well as on all types of electrical machinery.

Elastic Stop nuts are available in sizes ranging from a watchmaker's 0-80 through 3″, and in many standard finishes and materials including carbon and stainless steels, brass, duronze and aluminum.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA

also maker of the ROLLPIN TRADEMARK

*The Red Locking Collar is a Registered Trademark of ESNA

Elastic Stop Nut Corporation of America
Dept. N27-94, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Company_____

Street_____

City_____ Zone___ State_____

Circle 466 on page 19

SEALING DOMESTIC APPLIANCES IS A REAL CHALLENGE, TOO!
Standard 6A Seal with specially designed seat conforming to impeller contour so as to promote good water flow characteristics.
Limited axial room and large diameter are mechanical requirements in this washing machine seal. Design features multiple spring construction for even face loading.
FIVE ADAPTATIONS OF THE John Crane® TYPE 6A SEAL for four different appliance manufacturers
Seal features outer periphery face construction to best service garbage disposal conditions.
Two sealing points in a washing machine with widely differing physical limitations, yet seals for both retain full advantage of diaphragm action, shouldering points and positive drive.

Soapy water, detergents, bones, grit and lint . . . all these combine to make appliances a hard-to-handle sealing problem. Add that to a very limited space factor, and you've got a real set of conditions on your hands.

"John Crane" engineers have solved these problems and thousands of other shaft sealing applications on all types of commercial and industrial equipment. We know that we can be of the same help to you.

That's why . . . as one design engineer to another . . . we urge you to let us work with you in adapting or developing the proper seal for your application.

Tell us about your requirements or write for our fully illustrated Bulletin S-204-3 on "John Crane" Shaft Seals.

Crane Packing Company, 6425 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

Helpful Literature

production information on machining, forming, and welding are outlined in this illustrated "Fact File." Much data are in tabular form. 24 pages. Mallory-Sharon Titanium Corp.

Circle 635 on page 19

Cellular Rubber

Properties and test data on various types of cellular rubber are content of illustrated brochure 762. Various grades offered, special purpose stocks, and specifications are detailed. Much data are in graph and table form. 28 pages. B. F. Goodrich Co., B. F. Goodrich Sponge Products Div.

Circle 636 on page 19

Whiteprinting Machine

Specifications, features, and advantages of Streamliner 200 whiteprint machine are presented in illustrated bulletin. Table model unit handles materials of any length up to 42 in. wide. Receiving tray stacks 24-in. long materials. General Aniline & Film Corp., Ozalid Div.

Circle 637 on page 19

Hydraulic Components

Hydraulic pumps and motors, motorpumps, and hydraulic packages miniaturized for missile applications are detailed in illustrated bulletin A-5216. Specifications of each unit are given. 4 pages. Vickers Inc.

Circle 638 on page 19

Corrosion Resistant Alloys

Chemical compositions and physical, mechanical, and high temperature properties of Hastelloy B, C, D, and F nickel-base alloys are given in comprehensive booklet. Table compares their resistance to over 250 corrosives commonly used in various industries. Laboratory penetration data for corrosives and section on techniques for forging, cold working, machining, grinding, and welding are also included. 104 pages. Haynes Stellite Co.

Circle 639 on page 19

High Temperature Alloy

High temperature strength data for Croloy 18-8 Ti (AISI type 321) are presented in Alloy Sales Letter No. 288. Chemical compositon, tensile properties, results of a test program, design data, creep-rupture properties, and applications for tubing made from the material are cov-

Why should you pay for top quality in "Commercial Grade" Roller Bearings . . . AND NOT GET IT?

It's *wasteful* to pay for quality you don't need. It's *negligent* to pay for quality you don't get.

From the simplest steel-cage type to the finest segmented-retainer type, Rollway "commercial grade" Tru-Rol Roller Bearings incorporate as closely as possible design and construction principles found normally in a Rollway maximum-type precision bearing.

Take the segmented-type Tru-Rol for example. Each deep-section separator segment is formed to fit the curvature of the roller. Each roller has a separator segment to keep it in accurate alignment. And each roller is crowned to distribute load evenly along the full length of the roller.

That's a lot different from small-diameter, unground spacers staggered at unequal intervals, resulting in rollers rubbing in opposed-motion, and non-uniform roller distribution that can set up out-of-balance vibration and "pulse".

Let a near-by Rollway Service Engineer consult with you on your bearing problems. No charge. No obligation. Just write us. Rollway Bearing Co., Inc., Syracuse, N. Y., *manufacturers of a complete line of radial and thrust cylindrical roller bearings*

Cutaway view of Rollway Tru-Rol® segmented-retainer roller bearing . one of three distinct types of Tru-Rol bearings available.

ENGINEERING OFFICES: SYRACUSE • BOSTON • CHICAGO • DETROIT • TORONTO • PITTSBURGH • CLEVELAND • MILWAUKEE • SEATTLE • HOUSTON • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

Check This List AND BE SURE!

Retainer Operation

☐ Is the retainer roller-supported, to reduce sliding friction?

Retainer Construction

☐ Is the retainer strong enough to withstand shock loads and sudden reversals?

(A Rollway segmented-type steel retainer, such as that illustrated, is the strongest, most durable available in commercial grade bearings.)

Roller Spacing

☐ Are all rollers equally separated, or do some rub against each other in opposed-motion friction?

☐ Are rollers distributed evenly to prevent "pulse" and vibration?

Roller Construction

☐ Are the rollers crowned for optimum load distribution?

For Top Quality in Every Detail Buy Tru-Rol and Be Sure!

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

PRECISION MACHINE SCREWS

Make it Easier to Sell!

. . . because with high quality fasteners your product earns a reputation for better performance and longer life service. Experience proves that the initial higher cost of quality components is offset time and time again by such things as operating efficiency, good appearance, better accuracy, etc.

Better Steel means Better Quality

The carbon steel heading wire used in the production of standard Hubbell Screws is A.I.S.I. Grade C-1010. Special application screws with higher strength or torque value requirements are produced from A.I.S.I. Grades C-1013, C-1020 and C-1035. Those subjected to drilling or subsequent tapping operations are produced from A.I.S.I. Grades C-1108 or C-1110.

All carbon steel wire used in the production of Hubbell screws, regardless of grade, is annealed in process material to specified tensile strength and is drawn to restricted size tolerance to insure the high Hubbell standards of quality and size in the finished screws.

Prices and delivery on request. Simply send blueprint or sample of the item.

HARVEY HUBBELL, INC.

HIGHEST QUALITY WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

Circle 469 on page 19

Helpful Literature

ered. Comparative prices are given. 5 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 640 on page 19

Self-Locking Nuts

Comparison charts in illustrated bulletin 5711 show weight, size, temperature, and material for miniaturized self-locking nuts for electronic units and avionic equipment. Hex and clinch series are covered. Specifications of each type are given. 36 pages. Elastic Stop Nut Corp. of America.

Circle 641 on page 19

Oiltight Control Units

Pushbuttons, indicating lights, selector switches, Roto-Push buttons, covers and enclosures, and accessories are described in illustrated, spiral-bound, fold-out catalog "Master Design." Specifications and application data are presented. Molded buttons are offered in six bright colors. 26 pages. Cutler-Hammer Inc.

Circle 642 on page 19

Halofluorocarbon Polymers

Over a dozen tables of properties are included in technical booklet on Kel-F halofluorocarbon polymers. Material is stable, resistant to range of temperatures, chemically inert, and a true thermoplastic. Application data are presented. 10 pages. Minnesota Mining & Mfg. Co.

Circle 643 on page 19

Forged Steel Fittings

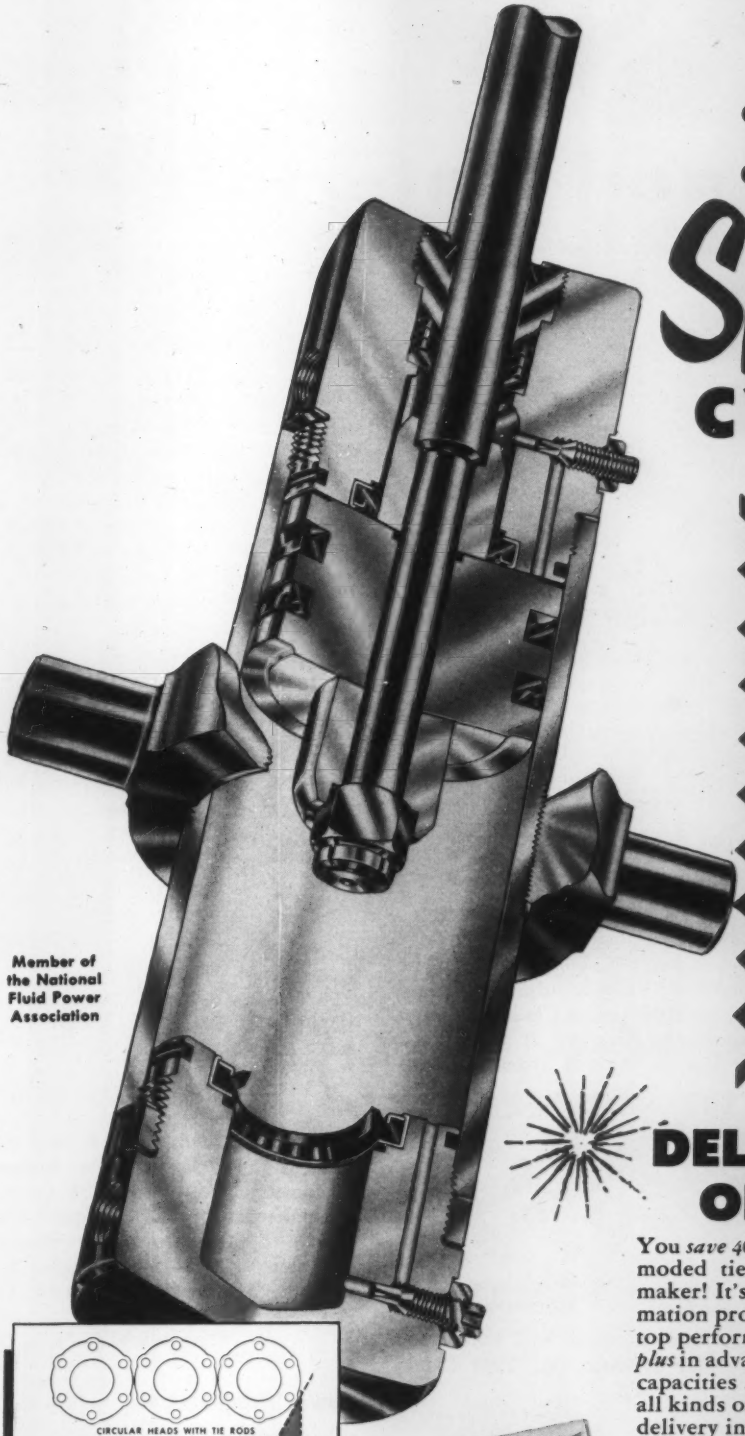
Data on packaging concept for W-S forged steel pipe fittings is presented in bulletin PF-1-57. Included are quantities of each type and size of each fitting in packages. Packaging system insures protection of fittings in transit and provides method of inventory. 4 pages. H. K. Porter Co., W-S Fittings Div.

Circle 644 on page 19

Slide Computer

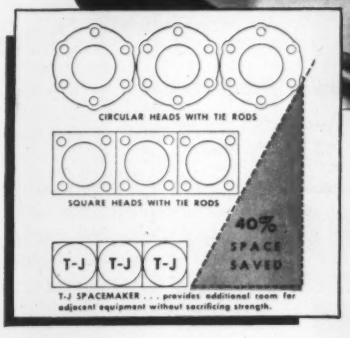
Ordinary slide rule computations as well as rapid solutions to formulas involving two variables, raised to any power or root, and a constant are performed readily with the Graham Handy Horsepower Computer. Accompanying the computer is a booklet "Fascination in Numbers" for engineers and designers. Computer and booklet will be sent free to those writing on their business letterhead to: Graham Transmissions Inc., Menomonee Falls, Wis.

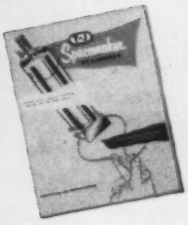
all the EXTRAS are standard with T-J Spacemaker CYLINDERS



- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.

Member of the National Fluid Power Association


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
T-J
T-J
T-J
40% SPACE SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.



DELIVERY OFF THE SHELF!

You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHERS

Circle 470 on page 19

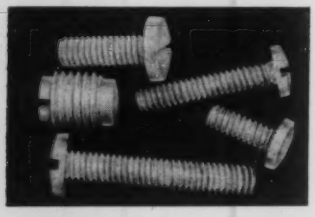
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Nylon Screws

are high-strength, molded units

Nylon screws, molded one at a time, are completely identical in all dimensions and can be made to close tolerances. Stock sizes for machine screws are 6-32, 8-32 and 10-32, with lengths from 3/8 to 1 in. Headless setscrews to 5/16 in.



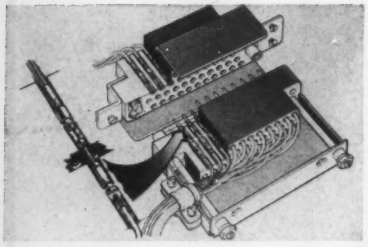
OD and 13/32 in. long are also available. Threads are Class 2, unified standard. Screws have high strength-to-weight ratio, stability over a wide temperature range, and chemical and corrosion resistance. They are nonmagnetic, nontoxic, fungusproof, and will retain shape after sterilization. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y.

Circle 645 on page 19

Electrical Connectors

rectangular units have snap-in contacts

Rectangular electrical connectors have applications in the electrical, electronic and aviation industries. Removable snap-in contacts have retention springs which permit attachment of contacts to wires prior to installation in connector body. Split-hood design facilitates assembly, inspection and contact replacement or rearrangement. Connectors meet specification MIL-C-8384A for rectangular connectors.



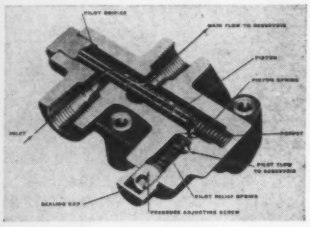
They are available in 34, 42, 50 and other standard contact capacities. **Consolidated Electrodynamics Corp.**, 740 Salem St., Glendale, Calif.

Circle 646 on page 19

Relief Valve

is adjustable from 500 to 2000 psi

Pilot-operated relief valve provides instant reaction, clogfree and silent operation. Valve is adjustable from 500 to 2000 psi and has maximum capacity of 20 gpm. It is designed for use in the lift truck, agricul-



tural and machine tool industries. **Webster Electric Co.**, 1900 Clark, Racine, Wis.

Circle 647 on page 19

Back-Up Rings

are Teflon units for use with O-ring seals

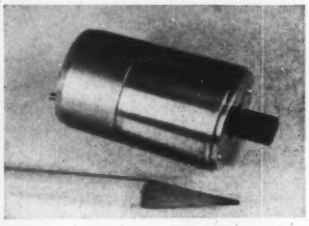
Teflon back-up rings, used with rubber O-rings in hydraulic and similar pressure systems, provide a better seal, less wear on O-ring, and eliminate deforming of O-ring by extrusion under pressure. Teflon rings are chemically inert, resist corrosion and heat, are flexible, and have low coefficient of friction. **Sparta Mfg. Co.**, R. D. 2, Dover, Ohio.

Circle 648 on page 19

Miniature Motor

is rated 1/100-hp at 10,000 rpm

Model P2P11A miniature 12-16 v dc motor operates in dry nitrogen gas at 30 mm Hg pressure absolute for 200 hr. Rated 1/100 hp at 10,000 rpm, motor draws 2.5



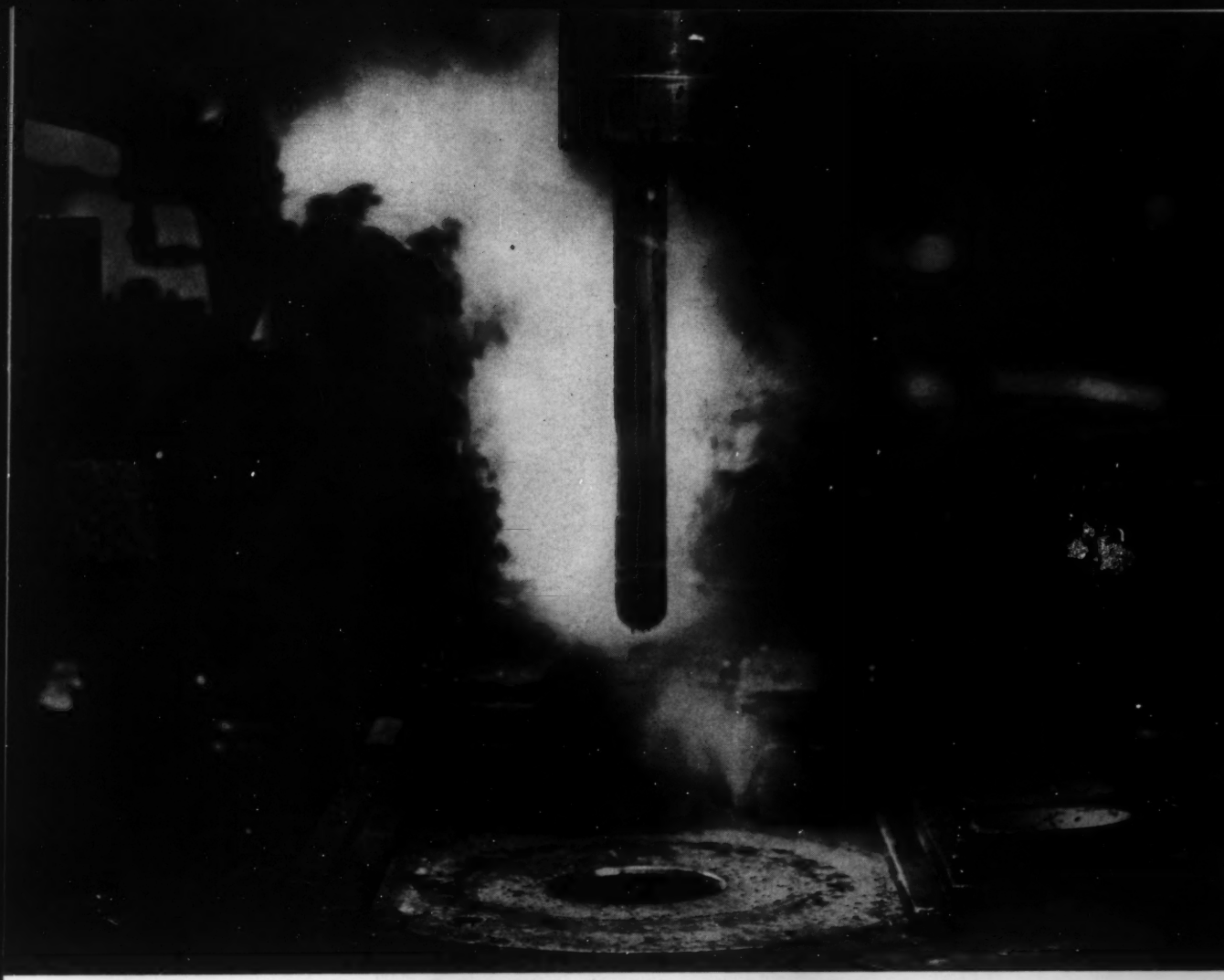
amp at full load and 0.7 amp no load. It develops 1.0 oz-in. torque in continuous duty or 1.85 oz-in., intermittent service. Designed for missile application, motor has a diameter of 1.127 in. and is 1.750 in. long. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif.

Circle 649 on page 19

Power Programmer

for direct actuation of power devices

Lightweight power programmer controls 24 separate circuits without complication. Designed for direct actuation of power devices, unit is unaffected by 5 *g* acceleration, 15 *g* impact shock, and vibra-



Tough 2½" diameter mandrel at Rc 44 on 1150 ton brass extrusion press. Scovill Manufacturing Co.

Mandrel of HALCOMB 218 retains toughness and hardness at hot work temperatures...

This mandrel is made of Halcomb 218—a tough, air-hardening hot work steel. Halcomb 218 is suitable for tools like this which require a higher degree of toughness at moderately elevated temperatures than is obtainable with the tungsten types of hot work steels. And Halcomb 218 *retains both* its hardness and strength at these temperatures.

For example, at a hardness of Rc 44, Halcomb 218's Charpy Impact Strength is 33 ft-lbs at 500F. And it will retain this hardness after 1 hour, after 10 hours and even after 100 hours at temperatures up to 900F.

Properties like these cut tooling costs. The mandrel shown above is good for 1200 pushes, for example, and even then all it needs, usually, is repolishing before being used again.

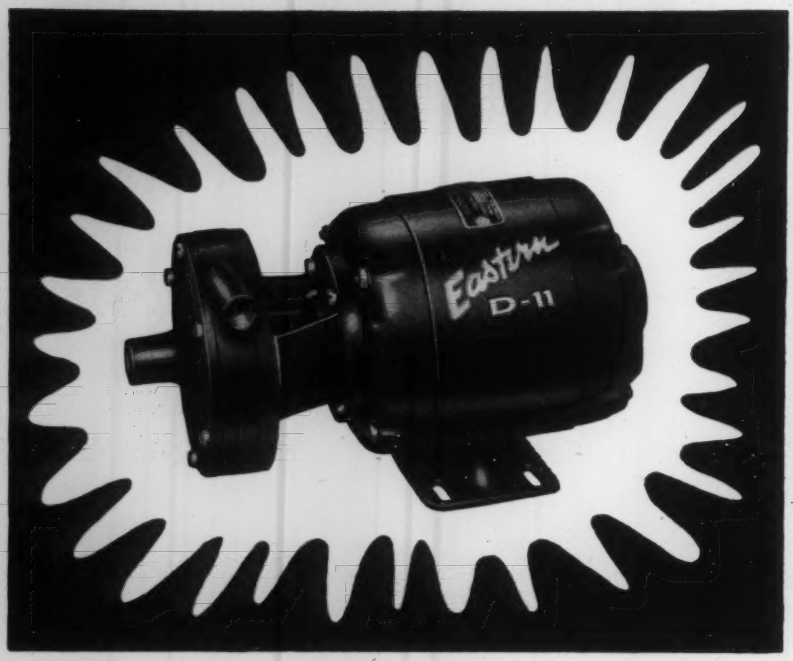
Halcomb 218 is particularly useful for all hot work operations on which drastic coolants are used. It even resists breaking very successfully when water cooled in operation. If these sound like advantages you can use, call your local Crucible representative for more complete data. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Circle 471 on page 19



24,830 successful installations!

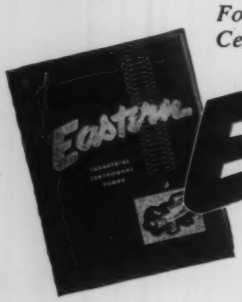
EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

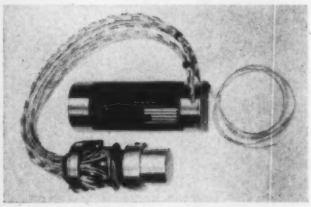
A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-G



Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

New Parts



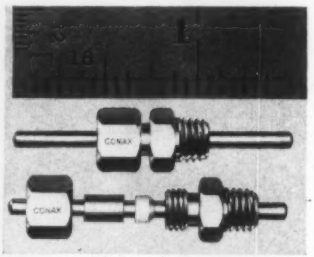
tion of 50-600 cps at 0.05 double amplitude. It has a diameter of 3 in., and is 9 in. long. Programmer is for use in missile firing control, missile guidance control, and industrial electronic equipment. **Mason Electric Corp.**, 3839 Verdugo Rd., Los Angeles, Calif.

Circle 650 on page 19

Miniature Packing Gland

is only 21/32 in. long

Micro packing gland seals tubes of any material, including ceramic, stainless steel, aluminum, brass or glass. Increased fatigue strength and resistance to vibration is assured by reduction of stress concentration at point of seal. Temperature range with Teflon sealant is −90 to 500 F; seal pressures range from 0.005 mu to 1000 psi. With Lava sealant, temperatures range from −300 to 1850 F with pressures from 0.005 mu to 3000 psi. Standard bore sizes are



1/16 and 3/32 in. with 1/16-in. IPS thread. Gland is 21/32 in. long. **Conax Corp.**, 2300 Walden Ave., Buffalo 25, N. Y.

Circle 651 on page 19

Pressure Switch

has sealed pressure-sensing chamber

GIS-8000 is an industrial pressure switch of aircraft quality for use in machine-tool control panels, hydraulic test stands and lubrication systems. The vibrationproof unit

Circle 472 on page 19

4-star feature with Drive-in Movies...

SPEED NUTS® simplify heater maintenance

Right from the start, the Electromode Division of Commercial Controls Corporation, Rochester, designed Tinnerman SPEED NUTS into their new electric car heaters for drive-in theaters. SPEED NUTS provide efficient, economical attachments that simplify servicing and give Electromode a powerful sales advantage with theater owners.

Four "U" Type SPEED NUTS hold the weather-tight steel cover firmly in place. SPEED NUTS eliminate the need for welding, staking or tapping. Self-retained, they stay in position even when the cover is removed for inspection or servicing. They "float" in the panel to offset hole misalignment. And because of their unique design, SPEED NUTS never rust or freeze to screw threads even under prolonged outdoor exposure.

This is a prime example of the advantages gained by designing with SPEED NUT Brand Fasteners in mind. Peak fastening efficiency is built in—no need to invest in high-cost tooling at the start, or to make revisions to cut costs later. Call in your Tinnerman representative now to discuss your new design projects. He can help you save time and money without sacrificing product quality. His office is listed in most major telephone directories. Or write to:

TINNERMAN PRODUCTS, INC.
P. O. Box 6688 • Dept. 12 • Cleveland 1, Ohio

TINNERMAN

Speed Nuts®

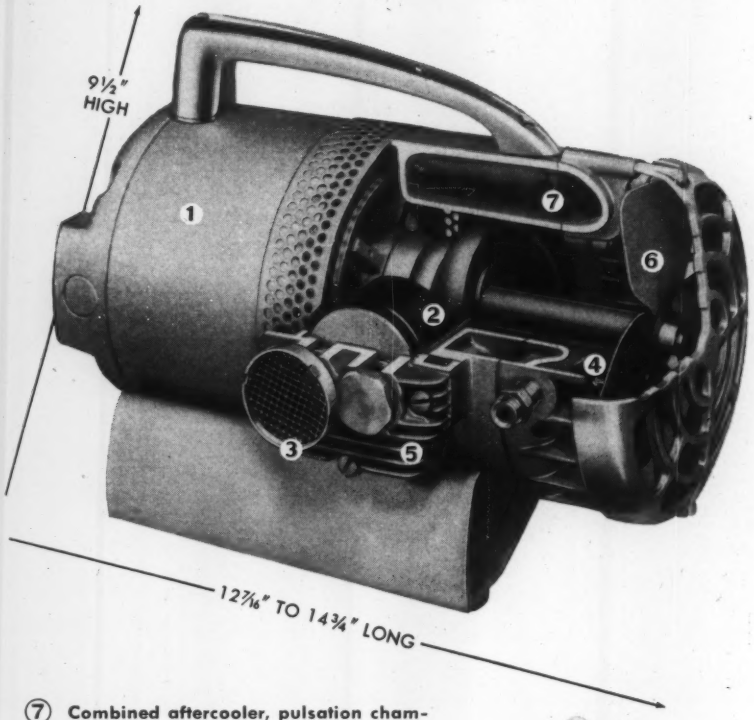
FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Oil-Free COMPRESSED AIR

from a portable or built-in unit

No more oil-spoiled work! Here is a compressor which doesn't require lubrication of any kind—eliminates an oil separator, *ends expensive lubrication maintenance!* Whether your need is for a portable or built-in source of compressed air, the compact, lightweight B&G Oil-less Compressor assures cleaner, cooler, drier air and smoother operation.



① **Specially designed motors.** Built by B&G—noted for dependability. Ball bearings are *permanently* grease packed.

② **Graphite piston rings and skirts.** Made of a special composition which does not need lubrication. Operate for years without destroying the mirror-finish of the cylinder walls. Piston ring joints are self-sealing—reduce blow-by to a minimum.

③ **Dry valve construction.** Inlet and exhaust valves are positive-sealing without presence of oil. Precision lapped—self-cleaning—no rubbing parts.

④ **Safety valve.** (Not visible.) Provides constant bleed-off at maximum pressure. Also acts as automatic moisture drain.

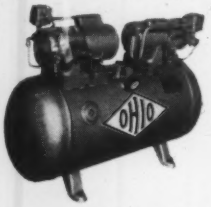
⑤ **Bi-metal cylinder head.** Deep-finned aluminum head transfers heat faster. It is cast around the cast iron cylinder, making a leak-proof shrink-fit...no gasket needed.

⑥ **Blast cooled.** The fan blasts great volumes of air over the pulsation chamber, connecting rods, bearings, cylinders and motor. Low temperature operation assures higher efficiency, longer life.

⑦ **Combined aftercooler, pulsation chamber, moisture separator.** Cooler, drier air is delivered at smooth, uniform pressure because of this integrated design.

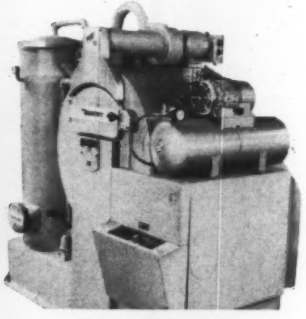
For complete information on B&G Oil-less Compressors and Vacuum Pumps, send for Catalog GO-1156

Cart mounted B&G Air Compressor



B&G "Duplex Unit" mounted on horizontal tank

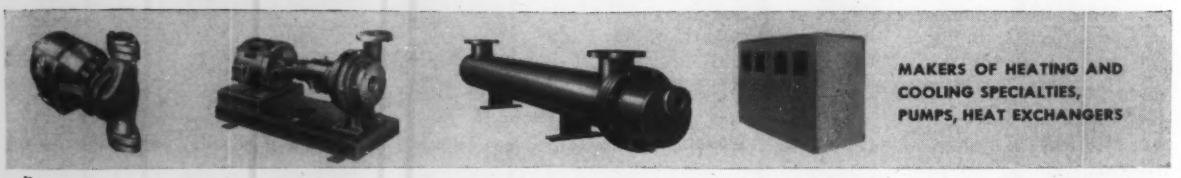
New type air stapler with air supplied by B&G Compressor



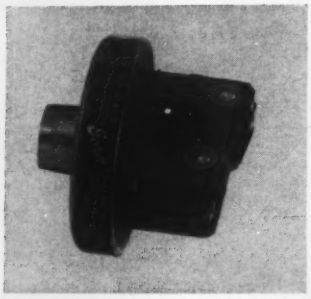
B&G Compressor built into dry cleaning machine

Oil-less AIR COMPRESSORS

BELL & GOSSETT
COMPANY
Dept. EY-67, Morton Grove, Illinois



has sealed pressure-sensing chamber which contains a diaphragm for use with a variety of fluids and gases. Switch makes or breaks electrical loads of 110/220 v to 15 amp in response to pressure



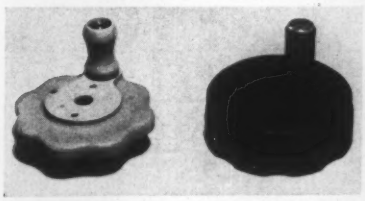
changes up to 225 psi with burst pressure to 600 psi. It is available for operation in temperatures to 275 F. **Gorn Electric Co. Inc.,** Gorn Electronics Div., 845 Main St., Stamford, Conn.

Circle 652 on page 19

Hand Cranks

in 1/8, 3/16 and 1/4-in. bore sizes

W-1 precision hand cranks are cast aluminum, chromic acid anodized. They are available in bore sizes of



1/8, 3/16 and 1/4 in. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, N. Y.

Circle 653 on page 19

Speed Reducers

for input speeds to 2000 rpm

Step-function speed reducers provide ten separate, repeatable speed ratios up to 1000:1. Any of ten speeds can be selected by turning selector knob without stopping input drive shaft. Gear-drive design assures precise repeatability of speed. Reducers are for input speeds to 2000 rpm and have torque capacities of 50 oz-in. on

(*Please turn to Page* 150)

3,800-pound impeller, shown as cast by NBD.

CALL THE MAN FROM **NBD**
FOR PUMP PARTS IN **BRONZE**

This impeller could be as big as 20,000 lbs. NBD makes pump castings any size, any shape! Housings, impellers, bushings . . . any weight up to 20,000 lbs. Machined to any degree of finish, up to 72-inch diameters. Precise tolerances held to your specifications.

NBD specializes in bronze metallurgy; has developed more than 40 special alloys. Completely equipped for shell mold, cast-to-size, centrifugal casting.

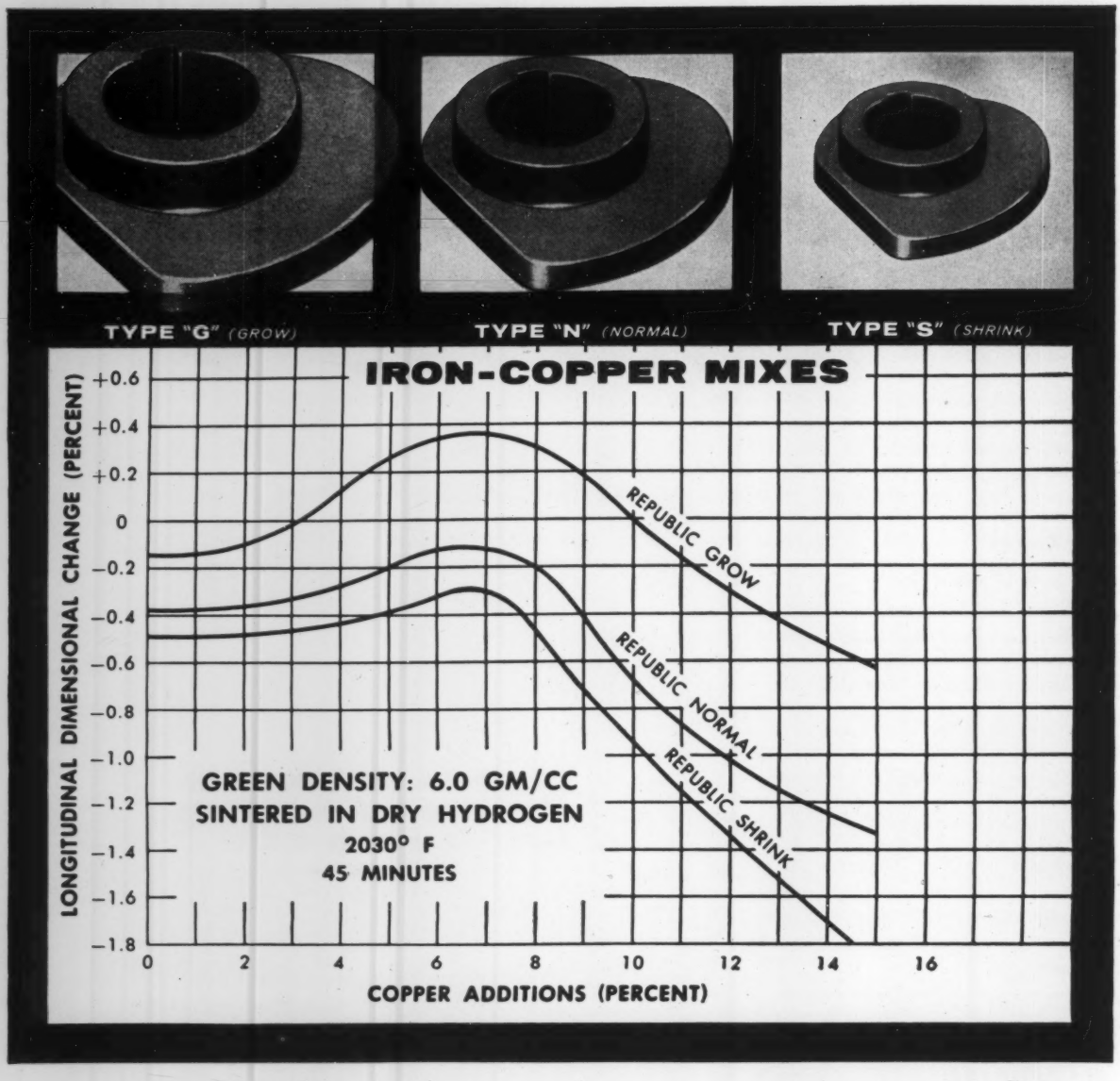
Call or write for quote or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
717 Grant Building • Pittsburgh 19, Pennsylvania
PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

Circle 475 on page 19

Republic Iron Powders



REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

with cdf

aid in establishing finish dimensions of parts

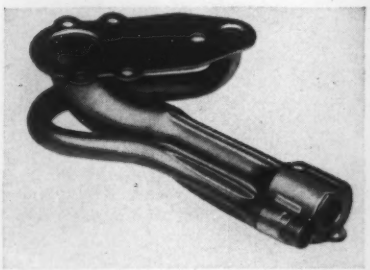
The chart, at left, shows the distinct dimensional change-characteristic that occurs when any one of Republic's three new Iron Powders —Type "G" for growth, Type "N" for normal, Type "S" for shrinkage—is blended with varying amounts of copper.

This change-characteristic is called *Controlled Dimensional Factor*—an exclusive Republic development.

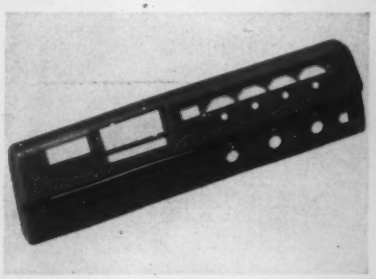
All values in this chart represent the average of numerous tests conducted by Republic's Metal Powder Division in the development of these new types of iron powder. In all cases, one percent zinc stearate was used as lubricant.

Republic Iron Powders with CDF can aid you in establishing the finish dimensions of parts. They can help you make better parts, reduce fabricating costs, and save on expensive die re-working.

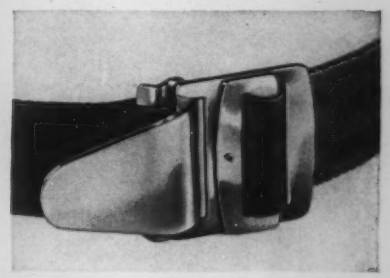
Our metallurgists and engineers will help you utilize all the advantages of Republic Iron Powder with CDF. There is no obligation. Mail the coupon to obtain their services or for more information on test evaluations, chemical compositions, and physical properties.



BETTER TUBULAR PARTS are made with Republic ELECTRUNITE® Welded Steel Tubing. Harper-Wyman Company uses it in making lightweight, easy-to-clean venturi burner tubes. The company subjects ELECTRUNITE to a hairpin bend of 1¼-diameter radius, then a four-way crimp, followed by punching, notching and welding. Uniform, predictable ductility avoids stretch and collapse as tubing is severely bent and formed. Close tolerances of O.D. and I.D. avoid die and mandrel troubles. Write for facts.



QUALITY STAMPED AND DRAWN PARTS such as this electric range control panel are produced by Republic's Pressed Steel Division. Complete service is provided from design to fabrication. Topnotch facilities, plus years of know-how and experience, assure you of the best product. Equipment is available for blanking, cold and hot forming, drawing—also for complete assemblies. We handle the heaviest gages used in industry, including carbon and alloy steel or nonferrous metals. Write for Booklet Adv. 681.



STRONG, SAFE PARTS are fabricated from Republic ENDURO® Stainless Steel. Bunke-Musser Company uses Type 201 for this seat-belt buckle. Fabricating operations include shearing, punching, and severe bend of 175° to form the pelican hook. The company had tried carbon steel, but this required a heavier gage, chrome plating and polishing, with the end result being more expensive than stainless. Republic Type 201 provides strength, safety, wear-resistance, and workability. Write for booklet on the 200-Series stainless steels.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. C-3552A
3130 EAST 45th STREET • CLEVELAND 27, OHIO

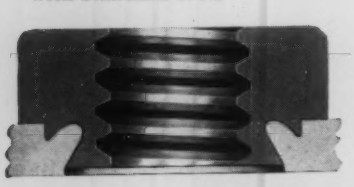
☐ Send more information on Republic Iron Powders with CDF.
☐ Have an engineer call.
Send additional information on:
☐ ELECTRUNITE Welded Steel Tubing ☐ Stampings
☐ ENDURO Stainless Steels (200 Series)

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 476 on page 19

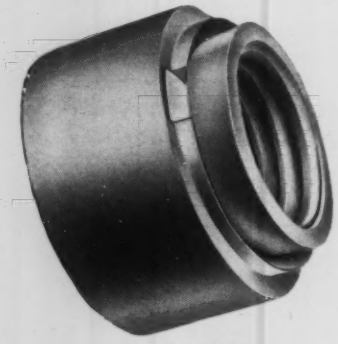
clinched—

. . . one or several at a time, with standard tools



by a squeeze—

that permanently locks it into the sheet metal and leaves reverse side flush



—with the greatest of ease

. . . one or several at a time for fast assembly and lower costs.

PEM

SELF-CLINCHING FASTENERS

The standard of many leading manufacturers for providing load carrying threads in steel, aluminum, copper or brass sheet "too thin to thread".

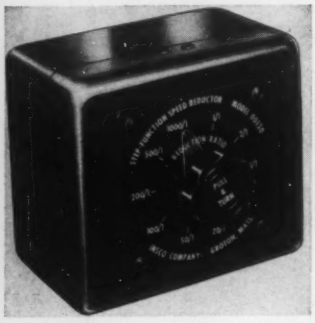
Write for new catalog that describes the 6 types in four different metals of construction—and samples for test. Penn Engineering & Manufacturing Corp., Doylestown, Pa.

PEM

Circle 477 on page 19

New Parts

(*Continued from Page* 147)



output shaft. Units can be panel or base-mounted. **Insco Co.**, Div. of Barry Controls Inc., Hollis St., Groton, Mass.

Circle 654 on page 19

Clear Plastic

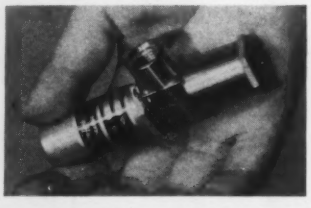
withstands temperatures to 200 F

CR-39 transparent plastic material can be sawed, drilled, bored and machined easily. It withstands constant temperatures to 200 F, has excellent weathering characteristics, high impact strength, and is not brittle at low temperatures. Material is used for instrument glazing, industrial mirrors, display cases, transparent partitions, windows and safety shields. It is available in sheets to 48 x 60 in. in thicknesses from 1/16 to 1 in. **Homalite Corp.**, 15 Brookside Drive, Wilmington 4, Del.

Circle 655 on page 19

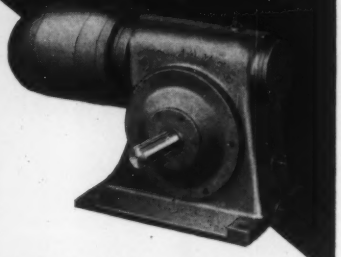
Pressure Reducer

miniature unit is completely balanced



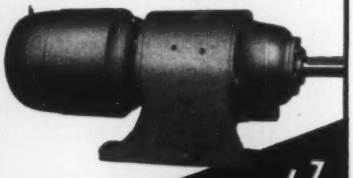
Miniature pneumatic pressure reducer with ¼-in. ports is designed to reduce pressure from 3000 psi. Unit is available with or without built-in relief valve and is adaptable to hydraulic application. It is completely balanced, producing straight-line regulation, with leak-

D.O.James GEARMOTORS



RIGHT ANGLE GEARMOTOR—Horizontal or Vertical Drive, 8 sizes, ratio 6:1 to 100:1, ⅓ to 30 horsepower.

IN-LINE GEARMOTOR—Horizontal or Vertical Drive, 37 sizes, ratio 9.2:1 to 1200:1, 1 to 75 horsepower.



OUR 70th YEAR

THE D.O.James Gearmotors are of the same construction and high quality as the individual Gear Speed Reducers which we have been producing for so many years.

They cover a very wide range of ratios, horsepowers, and are an ideal, compact, efficient unit for many power and space-saving installations. They are designed and built by an organization that has been engaged in the manufacture of Gears for 70 years and that has successfully pioneered the Gear Speed Reducer to its present-day high standards.

D.O.JAMES
GEAR MANUFACTURING CO.
1140 W. Monroe Street, Chicago, Illinois

Since 1888

MAKERS OF EVERY TYPE OF GEAR AND GEAR SPEED REDUCER

SEND FOR CATALOGS

Catalogs, price lists and selection tables covering gear speed reducers and gearmotor speed reducers are available to power transmission engineers. Please request on company Letterhead — we'll mail your copy at once.

Circle 478 on page 19

STRONGEST—high-strength copper alloy for rugged strength. **MOST COMPACT**—the snuggest lug . . . easier terminating in tight spots. A cinch to tape. **FASTEST**—insert cable, tighten smallest size with screwdriver; larger sizes with Allen wrench. **SAVINGS**—through **KA-LUG'S** ease of installation, greater electrical dependability . . . as well as low initial cost.

KA-LUG

new quality in a low-cost terminal . . .

the NEW "most-for-your-money" connector

type KA
available for No. 14 thru 500 Mcm.

SEND COUPON FOR FREE SAMPLE AND PRICE SHEET

BURNDY, Norwalk, Connect. Dept. D
Rush a sample of the new Burndy Ka-lug to me today.

NAME .....
FIRM .....
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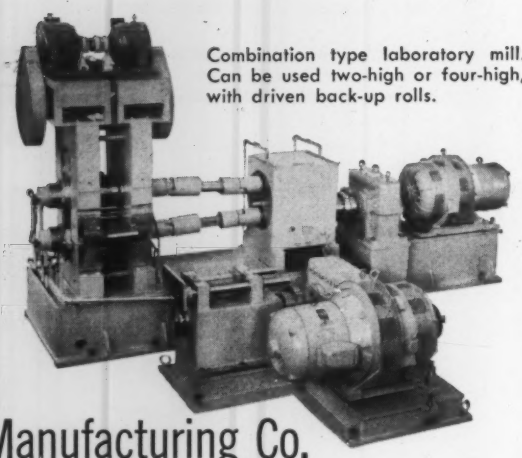
CITY ..... STATE .....

BURNDY

56-21A

Norwalk, Connect. • Toronto, Canada • Other Factories: New York, Calif., Toronto • Export: Philips Export Co.



Combination type laboratory mill. Can be used two-high or four-high, with driven back-up rolls.

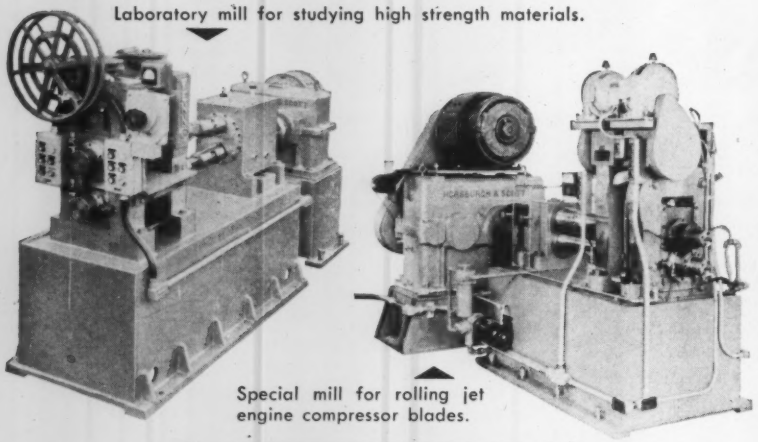
Why
Fenn Manufacturing Co.
equips its precision rolling mills with
H & S Speed Reducers and Gears

Manufacturers of precision metal forming equipment, the Fenn people necessarily must buy carefully when selecting components from other sources. When it comes to speed reducers and worm and gear sets, they rely on *Horsburgh & Scott.*

The Fenn rolling mills illustrated here are built to order for both production and laboratory use. H & S Speed Reducers are in evidence, sized to suit the need. H & S worm and gear sets are used in the screw down mechanisms.

The rugged dependability of H & S products, helpful and flexible engineering service, and reliable delivery performance are principal values in a continuing profitable relationship . . . There's a solution to *your* power transmission problem in the broad lines of gears and assembled units made by H & S. Write us, or contact your nearby H & S representative.

Laboratory mill for studying high strength materials.



Special mill for rolling jet engine compressor blades.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

New Parts

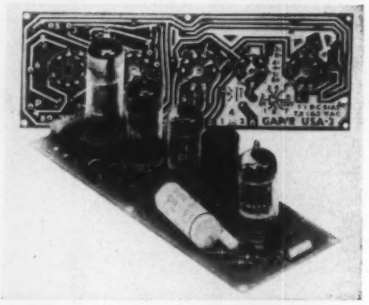
tight shut-off, high rated capacity, and small initial pressure drop under flow conditions. Normal temperature range is −65 to 225 F. Reducer conforms to MIL-R-8572A. **Pneu-Hydro Valve Corp.,** 364 Glenwood Ave., East Orange, N. J.

Circle 656 on page 19

Amplifier

is chopper-stabilized unit

Printed-circuit universal stabilized amplifier, designated Model USA-3, has applications in instrumentation, control, and analog computation. Chopper-stabilized unit has open-loop dc gain of 10 million and output range of ± 115 v. When unit is used at a gain of 100, accuracy is maintained beyond 1 kc. Printed-circuit board measures 7 x 2½ in. and amplifier connection



scheme is permanently etched into the board. Basic unit is designed for mounting in any fashion, and several types of modular packaging are available. **George A. Philbrick Researches Inc.,** 230 Congress St., Boston 10, Mass.

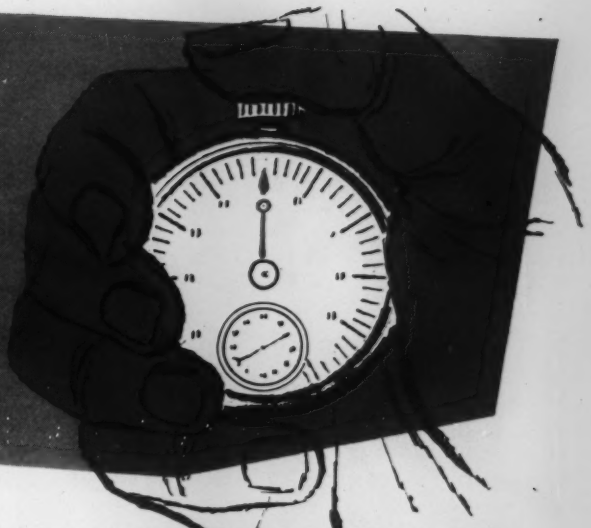
Circle 657 on page 19

Gear Motors

of double helical gear design

Line of integral horsepower gear motors and related transmissions is available in three basic components: an integral-type unit (shown); an all-motor type in which drive motor is coupled to gear reducer and mounted on a common carrier; and a separate helical speed reducer. Double helical gear design provides flexibility in application and ease of maintenance. Three basic types of speed reductions are available: single re-

how do you measure your production?



There is a *just-right* production speed for every job. Run a little faster and you'll have trouble—a little slower and your equipment is not being used efficiently. A Reliance V*S Drive will give you the *just-right* speed for each job.

Reliance V*S is an all-electric drive that operates from a-c. circuits. The operator varies the drive motor rpm. to set up the ideal speed for every job. With no rigid set of gear ratios with a limiting number of speeds, he has an infinite selection of rpm.'s from a wide flexible band of operating speeds.

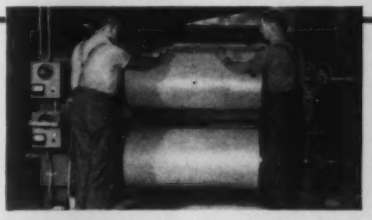
There is a V*S Drive designed for your equipment. Write for Bulletin D-2311.

• TONS PER HOUR

In order to maintain a uniform production rate of 80 tons per hour with varying sizes of pipe, this pipe mill must change its line speed from 30 ft. per minute to 80 ft. per minute to compensate for differing gauges of steel. A 500 hp. multi-motor V*S Drive does the job.

• YARDS PER MINUTE

In order to properly size differing types of cotton cloth, the textile slasher must operate at line speeds varying from 28 yds. per minute to 225 yds. per minute. A 25 hp. V*S Drive does the job.



• REVOLUTIONS PER MINUTE

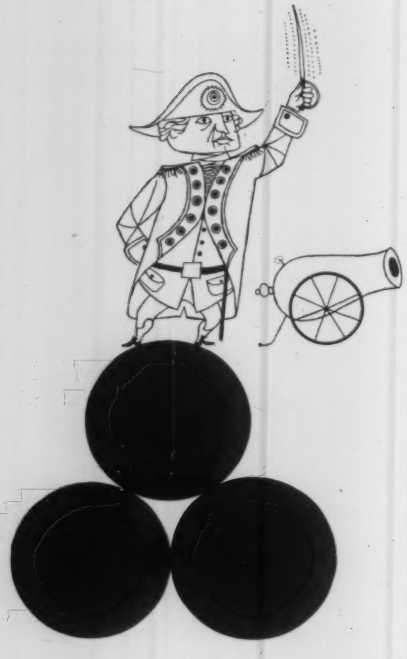
In order to maintain the correct tension on the metal on this highly accurate rolling mill, the speed of the coil winder must decrease from 900 rpm. to 450 rpm. as the diameter of the roll builds up. A 20 hp. V*S Drive does the job, automatically.

D-1563

RELIANCE ELECTRIC AND ENGINEERING CO.

Dept. 289A CLEVELAND 17, OHIO • CANADIAN DIVISION: WELLAND, ONTARIO

Sales Offices and Distributors in Principal Cities



Give 'em another round . . . !

John Paul Jones poured round after round of shot into enemy vessels, much the same as Universal pours out round *precision* balls for a variety of products in industrial applications. Whether metallic or non-metallic material, the classic Universal *Precision* Balls are perfect in every respect, with tolerances as fine as 0.000005 of an inch.

If it's a perfect round, it's a Universal Precision Ball.

UNIVERSAL QUALITY CONTROL—FOR ALL AROUND PERFECTION

Universal Ball co.

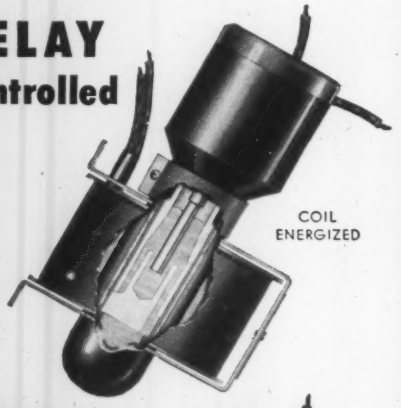
WILLOW GROVE, MONTGOMERY CO., PA.

Circle 482 on page 19

The **TIMER RELAY**

that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool

STEEL MERCURY TIMERS

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

See telephone directory for local distributor, or write.

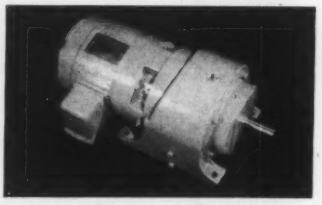
DURAKOOL, INC.

ELKHART, INDIANA, U. S. A.

700 WESTON RD., TORONTO 9, CANADA

Circle 483 on page 19

New Parts



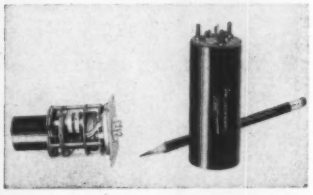
duction offset shaft in speed ranges from 780 to 350 rpm; double reduction concentric shaft for speeds from 350 to 37 rpm; and triple reduction concentric shaft for output speeds from 30 to 13.5 rpm. Integral-type gear motors have ratings from 1 to 30 hp. Separate helical speed reducers and all-motor units have ratings from 1 to 75 hp. **General Electric Co.**, Gear Motor & Transmission Components Dept., Paterson, N. J.

Circle 658 on page 19

Subminiature Timer

is hermetically sealed, motor-driven unit

Only 1½ in. square, this hermetically sealed timer is designed for 115 v 400 cycles, 115 v 60 cycles, and 28 v dc. Mounting mechanism is internally shock-mounted to meet applicable military specifications for shock and vibration. Unit



operates in a temperature range of −55 to 125 C and to altitudes of 60,000 ft. Weight of the timer is 6 oz. **Advanced Products Co.**, 59 Broadway, North Haven, Conn.

Circle 659 on page 19

Air-Line Filters

have automatic drain mechanism

Automatic-drain air-line filters have simplified drain mechanism, efficient liquid removal and wide pressure and temperature operating range. Filters operate at top efficiency at air-line pressures from 5 to 150 psi for transparent-bowl models and 5 to 250 psi for metal-

OILITE
IN AN AUTOMATIC WASHER HELPS BUILD CUSTOMER SATISFACTION -YET COSTS NO MORE
OILITE bronze agitator shaft bearing
OILITE bronze upper center post bearing
OILITE bronze rubber-mounted lower center post bearing
OILITE bronze thrust washers (2)
OILITE bronze pulley bearing
OILITE bronze thrust bearing
OILITE bronze water pump bearing
Photos courtesy Whirlpool-Seeger Corporation St. Joseph, Michigan
Another cost-saving application of Amplex Powder Metallurgy

Quality is a *must* for trouble free operation, continued customer satisfaction. And quality depends upon the excellence of every part, every component. For many years Whirlpool-Seeger has used OILITE center post bearings, agitator shaft bearings, water pump bearings and pulley bearings in their automatic washers. Whirlpool-Seeger uses these and other OILITE parts for very good reasons.

First of all, the manufacturer knows OILITE heavy-duty bronze bearings will meet specifications. Chrysler-Amplex precision production assures him OILITE bearings capable of carrying their loads safely, surely and quietly.

Then too, Chrysler-Amplex plant and facilities—largest and most complete of any in the metal powder fabrication industry—promises on-time deliveries in any quantity.

Moreover, in using OILITE bearings the manufacturer selects a product his customers know and respect for superior engineering.

Finally, this manufacturer, like a great many others, finds OILITE bearings—despite all their advantages—cost no more.

Chrysler-Amplex representatives and dealers are located in principal cities in United States and Canada. Let the nearby representative help you. Find him in the yellow section of your telephone directory under—"Bearings—OILITE."

CHRYSLER OILITE PRODUCT

*OILITE is a registered trademark

*Only Chrysler Makes Oilite**

AMPLEX DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

Representatives and dealers located throughout the world

BEARINGS • FINISHED MACHINED PARTS • PERMANENT METAL FILTERS • FRICTION UNITS • FERROUS AND NON-FERROUS METALS

Circle 484 on page 19

NEW...from WINSMITH SPEED REDUCERS

SHAFT MOUNTED WORM GEAR SPEED REDUCERS

SERIES "ST"
Torque Arm Type

SERIES "SF"
Flange Mounted Type

Now you can specify Winsmith performance, dependability and economy for applications requiring a shaft mounted speed reducer.

The new Winsmith "ST" and "SF" series require less space than conventional models because they eliminate the need for couplings and bed plates. Both series are currently available in three sizes . . . in ratios from 7½:1 to 77:1 . . . horsepower from .63 to 8.82 . . . maximum output torque range from 816 to 7678 in. lbs.

These new shaft mounted models also embody all the advanced engineering and construction features that make Winsmith Speed Reducers first choice for any application from 1/100 to 85 h.p.

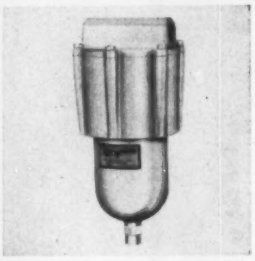
WRITE . . . FOR NEW CATALOG

For all the facts and complete technical data on Winsmith Shaft Mounted, Worm Gear Speed Reducers, write today—on your company letterhead, please—for Catalog No. SM-57.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

New Parts

bowl type. Float-controlled, pilot-operated drain mechanism discharges only when collected liquid reaches full capacity. Three interchangeable filter elements are available for removing abrasive solids from the air. Metal-bowl fil-



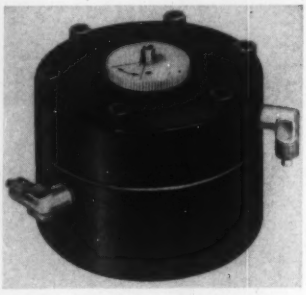
ter, available in ¼, ⅜ and ½-in. sizes, extends operating range to 200 F. **C. A. Norgren Co.,** 3400 S. Elati St., Englewood, Colo.

Circle 660 on page 19

Pressure Comparator

has service life of at least 500,000 cycles

Pressure comparator relates an unknown pneumatic signal to a reference pressure. When the two pressures reach an equilibrium, an electrical contact is opened. Leads from comparator can be used to indicate



a zero differential pressure. Unit is also suitable for use with any noncorrosive fluid. It has duration of service of at least 500,000 cycles. **Fischer & Porter Co.,** 92 Jacksonville Rd., Hatboro, Pa.

Circle 661 on page 19

Dial Assembly

is designed for low mass and inertia

BP-532 dial assembly indexes and indicates shaft rotations to 360 deg. It is a black-anodized alumi-

Circle 485 on page 19

Circle 486 on page 19→

GENERAL ELECTRIC ANNOUNCES

New Totally Enclosed D-c Motors

KINAMATIC* . . . to meet modern needs for faster, more automatic production in severe environments, General Electric announces a complete line of totally enclosed direct-current motors.

Designed for Tough Duty, d-c Kinamatic enclosed motors give you maximum mechanical protection *plus* the wide speed range and versatility required for close control of machines and split-second timing of processes.

Standard Mounting Dimensions of enclosed d-c Kinamatic motors save you time and money. With this better protected, more powerful direct-current motor, your machines will operate with less downtime . . . faster . . . easier . . . and with less maintenance.

Additional information is available at your nearest General Electric Apparatus Sales Office. Or, if you prefer, write for Bulletin GEC-1372, *Direct Current Motor and Generator Department, Erie, Pennsylvania.* 813-10

*Trade-Mark of the General Electric Company.

Progress Is Our Most Important Product

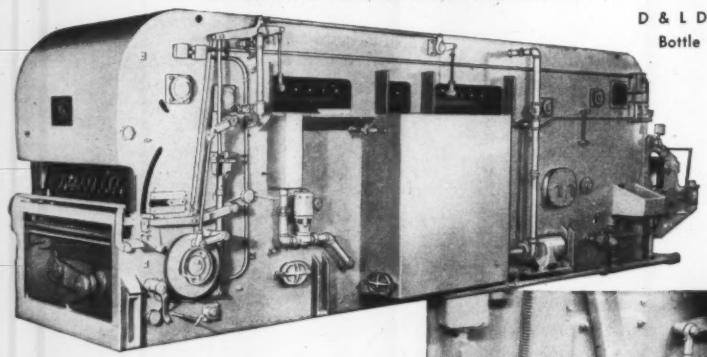
GENERAL ELECTRIC

Heim *Unibal* Rod Ends

compact . . . easily adjusted . . . bind-free

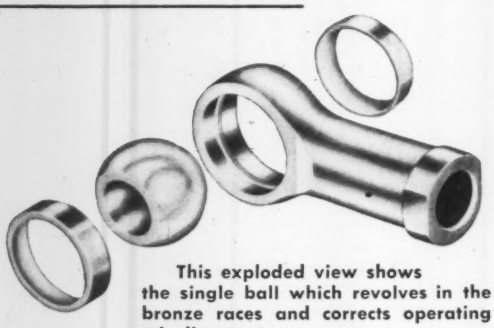
The Dostal & Lowey Company manufactures automatic bottle washing machines. There is a Single End machine of rugged construction which can be operated by unskilled labor; and there is a Double End washer of great speed and efficiency for high production.

The D & L Single End machine uses 28 and the Double End machine uses 14

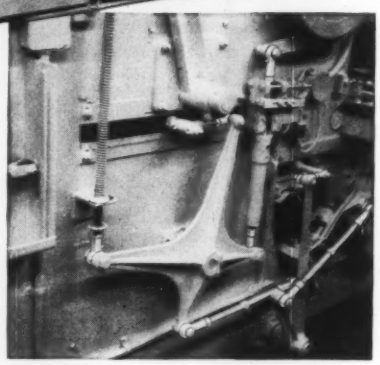


D & L Double End Bottle Washer

THIS → ← IS THE HEIM UNIBAL



This exploded view shows the single ball which revolves in the bronze races and corrects operating misalignments.



D & L Single End Bottle Washer

Have *You* considered the versatile Unibal for your linkages? Heim engineers will help you with suggestions and samples. The leading bearing distributors carry Heim Unibal.

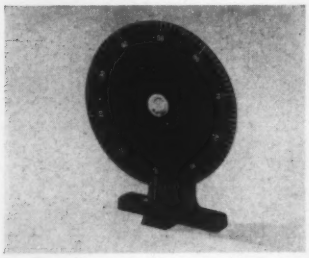
Unibal has many advantages, but those features which led D & L to choose Heim Rod Ends were their compactness, their ease of adjustment after installation, and the fact that they operate with a bind-free smoothness. The minimum maintenance (not a single failure or replacement in six years of use) and self-alignment of Unibal further improves the smooth operation of the D & L Bottle Washers.

The use of Heim Rod Ends in practically all motions of the machines has helped to bring out an important sales point — spare parts inventory is kept to a minimum.

PLEASE WRITE FOR COMPLETE CATALOG

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

Circle 487 on page 19



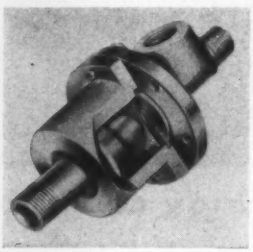
num disc, designed for low mass and inertia. Large 3-in. diameter face is easy to read and has 100 or 360 divisions. Bore diameter is ¼ in. **Beckman/Helipot Corp.**, Newport Beach, Calif.

Circle 662 on page 19

Rotary Joint

is easily installed, freezeproof unit

Exacto rotary joint will not seize or freeze on roll of dryers, mills or presses. It operates efficiently at steam pressures to 250 psi, with temperatures to 500 F and speeds to 1000 rpm. Flexible shaft alignment permits easy installation. Internal pressure relief design allows sealing members to function inde-



pendently of operating load. Sizes from ½ through 1½ in. are available. **Phillips Sales Co.**, P. O. Box 417, West New York, N. J.

Circle 663 on page 19

Magnetic Clutch-Brake

is miniature unit for low-power servomechanisms

Model D104 single-end magnetic clutch-brake meets military, environmental and performance specifications. Standard models, for application to low-power servomechanisms, operate on 24 v dc. Unit delivers a minimum of 8 oz-in. clutching and braking torque. Response

(*Please turn to Page* 162)

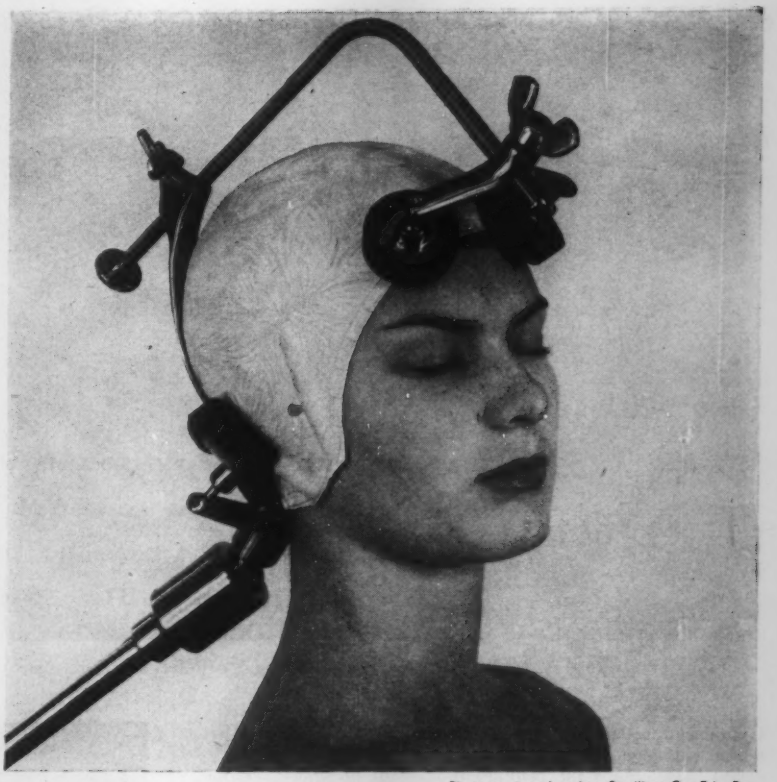


Photo courtesy American Sterilizer Co., Erie, Pa.

"Just What the Doctor Ordered"

New Super-Soft Rubber Pads Developed for Surgical Table Headrest

This surgical patient's head is in firm but gentle hands. The tight grip of the surgical table headrest shown above is now cushioned by super-soft (20 durometer) solid rubber pads. These pads are almost as soft as sponge but can be decontaminated and sterilized far more easily. Being made of neoprene, they are unaffected by oils, acids or decontaminating and sterilizing solutions. Furthermore, repeated sterilizing in live steam does not cause excessive hardening.

The neoprene compound specially developed for this purpose is 10 to 15 durometer points softer than normal commercial limits. For that reason, special care and skill must be taken in mixing and molding.

The successful development of this special purpose rubber part typifies the complete engineering and laboratory—as well as manufacturing—service offered by Continental.

Why not let Continental engineers consult with you in the planning or blueprint stage? Their specialized skill might help you get better rubber parts for your requirements.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these standard parts are shown in Continental's No. 100 Engineering Catalog. Send for a copy today. This catalog also is shown in Sweet's File for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

Circle 488 on page 19

Shaft Location Under High Radial Loads with Cylindrical Roller Bearings . . .

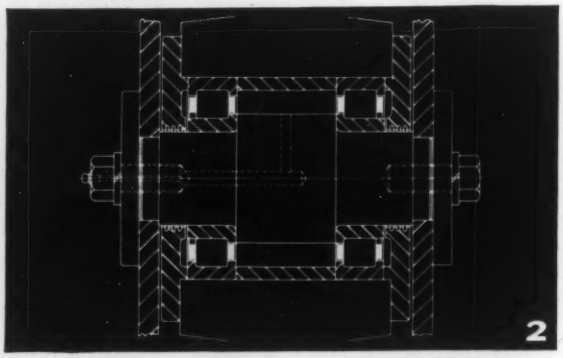
HYATT provides a variety of shouldered-race types to assure dependable shaft restraint in one or both directions . . . plus maximum radial load capacity

Cylindrical roller bearings have long been recognized by design engineers for their unequaled ability to sustain heavy radial loads. Since the primary movement of wheels, shafts or gears with respect to stationary housings in all types of machinery is *rotational*, the basic design of cylindrical roller bearings is relatively simple, and at the same time excellent for: a) Supporting heavy radial loads, and b) Positioning moving parts accurately with respect to their axes.

Less well recognized, however, is the ability of properly-built cylindrical roller bearings to perform most efficiently a third function frequently required of bearings: c) Locating moving parts laterally.

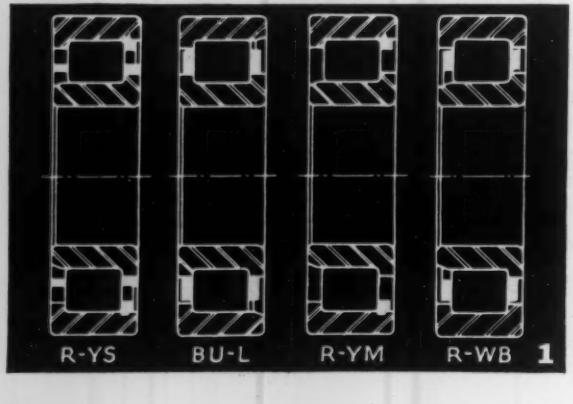
1. CHOICE OF BEARING TYPES

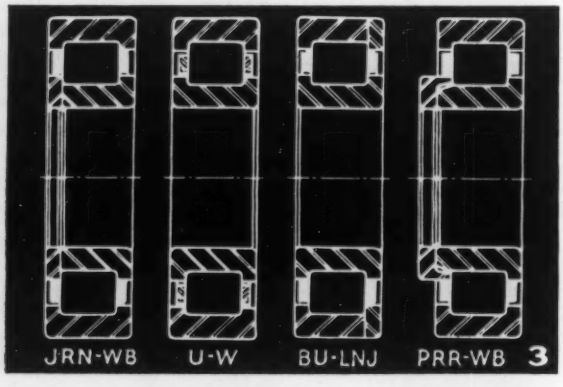
The design may require parts to be restrained laterally in one direction only, or in both directions, and this definitely determines the selection of bearings. Here the designer has a choice of types, depending on whether the machine elements favor one or two shouldered-race bearings. Whether inner or outer races are shouldered or whether assemblies are separable or non-separable has no effect on the ability of the bearing to perform its primary functions of supporting radial loads and positioning parts axially.

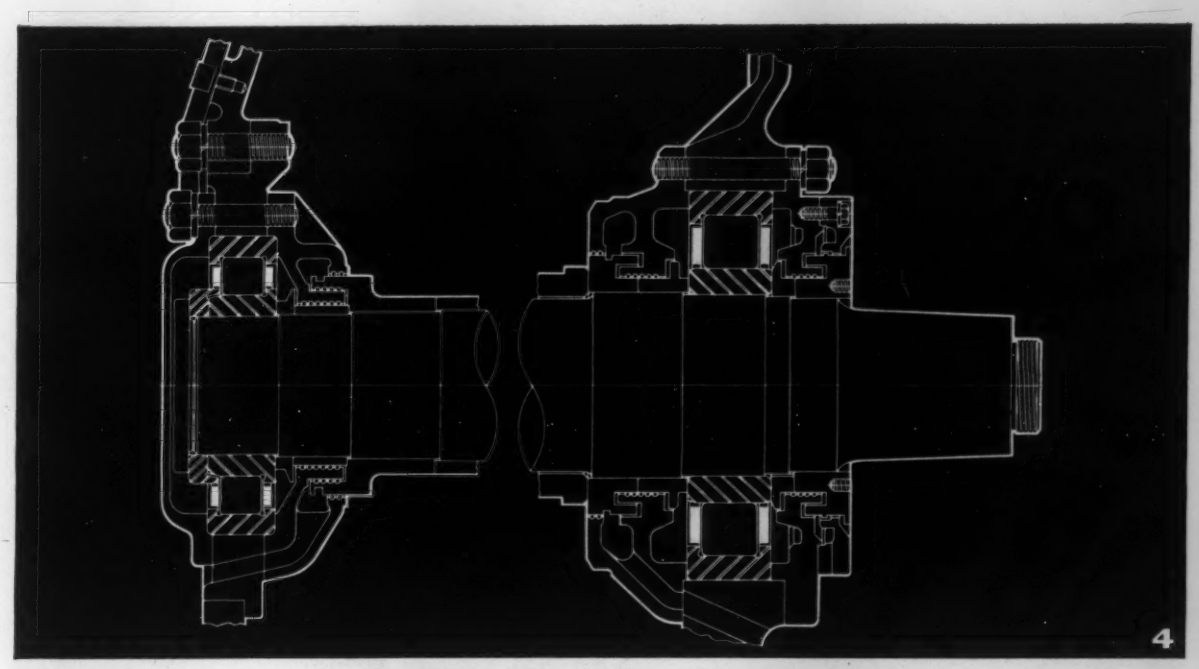


2. ONE-DIRECTION LOCATING BEARINGS

In most applications shaft location is accomplished by two opposing shouldered-race bearings, one restraining shaft movement in one direction and the other in the opposite direction. Depending on the conditions present, the designer has a choice of HYATT HY-ROLL types R-YS, BU-L,





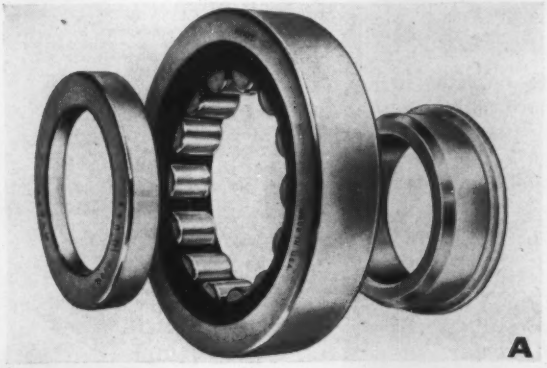


Diesel locomotive traction motor armature shaft with HYATT type PRR-WB at commutator end, type A-WB at pinion end.

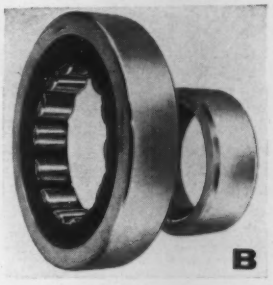
R-YM, R-WB (Fig. 1). Type RW-B, for example, has conclusively proved its shaft-locating dependability in heavy-duty service such as the armature shafts of steel mill motors and elevator cable sheaves. All four types are normally mounted in opposing pairs (Fig. 2). Sufficient end clearance is usually provided in the assembly to prevent binding in operation, particularly if temperature conditions cause the shaft to expand laterally.

3. TWO-DIRECTION LOCATING BEARINGS

Where the application indicates the use of only one bearing to locate a moving part in both directions, the designer may choose from HYATT Hy-Roll types JRN-WB, BU-LNJ and PRR-WB—or for relatively light loads, type U-W (Fig. 3). An outstanding heavy-duty application of type PRR-WB, for instance, is on the commutator end of diesel locomotive traction motor armature shafts. Used in this manner, the commutator end bearing relieves the pinion end bearing of all thrust forces, thus permitting it to function most effectively in supporting the heavy radial loads transmitted by the drive pinion. Type PRR-WB has a long record of excellent performance in this punishing service (Fig. 4 and Photo A).



4. PROVISION FOR SHAFT EXPANSION



Another advantage of using a HYATT bearing capable of locating the shaft in both directions is that it permits the shaft to expand laterally. When a HYATT type A-WB with straight cylindrical inner race, for example, is mounted on the other end of the shaft (Fig. 4 and Photo B), the shaft can expand laterally through it without binding the locating bearing.

To assure the simplest, most economical and dependable shaft location in one or both directions *without sacrifice of radial load-carrying capacity*, always specify HYATT Hy-Roll Roller Bearings. They will more than measure up to your requirements.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer for expert assistance. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; Oakland, California.

GM GENERAL MOTORS

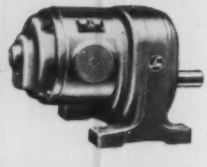
HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

Circle 489 on page 19

THE RIGHT ANSWER

for greater productivity from machinery investments

Sterling ELECTRIC POWER DRIVES



The important distinguishing features of Sterling Electric Power Drives can bring greater productivity and cost reductions to your manufacturing operations. To help you meet the competitive challenge of mechanization and automation, Sterling offers power transmission equipment, variable speed or constant speed—manual or automatic controls—and an application engineering service. Together, these give your machinery the type of drive systems that will achieve maximum productivity at lowest cost.

Sterling Speed-Trol Variable Speed Motors

Sterling Slo-Speed Gear Motors

Sterling Constant Normal Speed Motors

Sterling Multi-Mount Speed Reducers

Write today for Bulletin No. 185. Discover the big advantages Sterling Electric Power Drives can bring to your plant.

Sm

STERLING ELECTRIC MOTORS

LOS ANGELES 22 • CHICAGO 35
CINCINNATI 37 • NEW YORK 51

Circle 490 on page 19

New Parts

(*Continued from Page* 159)

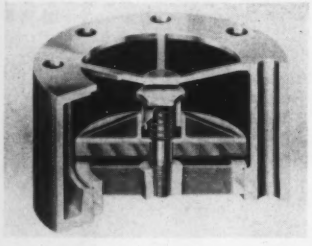
is as low as 3 milliseconds, and power consumption is 3 w. Mounting has OD of 1 1/16 in. **Dynamic Instrument Corp.,** 59 New York Ave., Westbury, L. I., N. Y.

Circle 664 on page 19

Check Valve

has spring-actuated internal disc

New check valve is for use where line surges and drop-back present a problem in fluid systems. Spring-actuated internal disc closes immediately as flow ceases and does not depend upon reverse flow for shutoff. Easily installed, valve has bearing guides on both sides of disc, and full-flow area that exceeds pipe area. Metal-to-metal or plastic-to-metal seating provides a



leakproof seal. Valve operates in any position. Standard sizes are from 2 to 18 in. for pressures to 2500 psi. **Combination Pump Valve Co.,** 850 Preston St., Philadelphia 4, Pa.

Circle 665 on page 19

Magnetic Counter

has electrical reset to any predetermined number

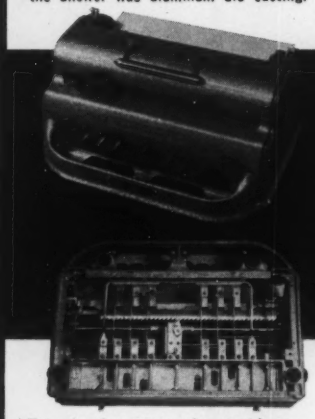
Model MCRP-700 is a high-speed precision counter which adds or subtracts electrical pulses with optional microswitch control at zero level. It incorporates electrical reset to any predetermined number. Lightweight armature, which actu-

PB = ?
PB = HB

Problem: What would be the finest type of casting for our Perkins Brailler which would be lightweight, rugged and low in cost . . . and where can it best be done?

Solution: Versatile Aluminum Die Casting . . . by Hampden Brass & Aluminum Co.

When the Perkins Institute for the Blind was faced with the problem of the best possible casting method to use for their Braille writer, they called on Hampden's 50 years experience and know-how . . . and the answer was aluminum die casting.



For the first time, the world over, a completely portable Braille writer was produced . . . cast in eleven die castings! Remarkably lightweight (Braille writer weighs only 9 lbs.) yet it has an embossing pressure of 40 lbs! The intricacies possible in aluminum die casting permit the castings to be held together by screws and nuts, the nuts being located in cored pockets. The flexibility of this arrangement allows the castings to be easily handled, enamel-baked . . . and assembled without any drilling or fitting.

Remember . . . whether your casting problems are big, tiny, intricate, or special . . . Hampden is ready to effectively solve them with premium quality castings of aluminum or other non-ferrous metals . . . utilizing the sand, permanent mold or die casting method. Our more than 50 years' know-how is your assurance of the best casting techniques to help reduce costs and improve performance.

Why not contact Hampden Brass & Aluminum Co. on your next casting problem . . . and avail yourself of our engineering counsel?

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden's experience, equipment and facilities.

HB

HAMPDEN BRASS AND ALUMINUM CO.

Established 1903

262 Liberty St.•Springfield, Mass.

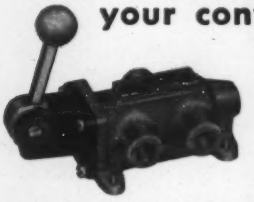
Producers of Sand, Permanent Mold, Die & Fiberglas Castings

Circle 491 on page 19

Schrader®...

your one source for AIR VALVES

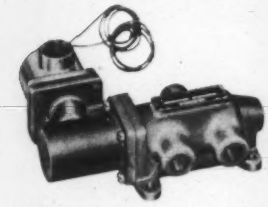
full line for every use—immediately available from your conveniently located Schrader Distributor



Hand-Operated Four-Way Valve

Foot-Operated Four-Way Valve

Pilot-Operated Valve



Solenoid-Operated Valve

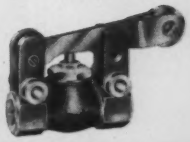
Rotor Type Valve

Cam-Operated Valves

Flow Control Valves

Quick Exhaust Valves

Two- and Three-Way Poppet Type Valves with Roller Lever



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QUALITY AIR CONTROL PRODUCTS

Pilot Your Way to LOWER COSTS and Higher PRODUCTION!

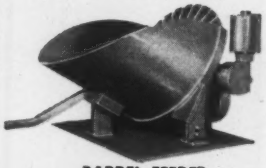
POWER SCREW DRIVERS
An extensive, versatile line in both bench and pedestal type.

Avoid the Reefs of Production Bottlenecks!

Use **DPS** PARTS FEEDERS and ASSEMBLY MACHINES

- The advantages are too great to overlook: Speed never before equalled . . . Economy . . . Greater Accuracy . . . and Stepped-up Profits. Write for catalog now . . . Tell us your problem . . . Send parts or assembly and our Engineering Department will make recommendations.

BOWL FEEDER
Electrical vibratory type to feed parts that cannot be tumbled.



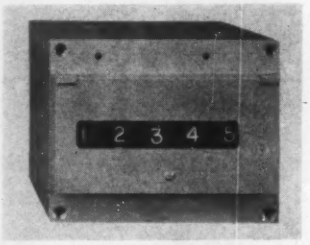
BARREL FEEDER
with stationary ring cover for heavy-duty production.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT STREET • DETROIT 26, MICHIGAN

New Parts

ates counting mechanism, is dynamically balanced to provide accurate counting under severe vibrations. Unit is available as a



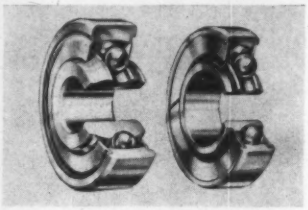
three, four or five-digit counter with any combination of add, subtract, and microswitch control at zero level. **Photocon Research Products,** 421 N. Altadena Drive, Pasadena, Calif.

Circle 666 on page 19

Precision Bearings

for aircraft control systems

Completely sealed and grease-lubricated bearings have full rows of balls and raceway curvatures to provide maximum load-carrying capacity. Self-aligning KS series, protected by permanently attached stainless-steel side shields, allows a misalignment of 10 deg in either direction. KP and KP-A series, not self-aligning, are protected by synthetic oil and grease-resistant seals held in place by stainless-steel split washers. Bearings are cadmium plated on all exposed surfaces. They



conform to Air Force-Navy aeronautical standards. **Norma-Hoffmann Bearings Corp.,** Stamford, Conn.

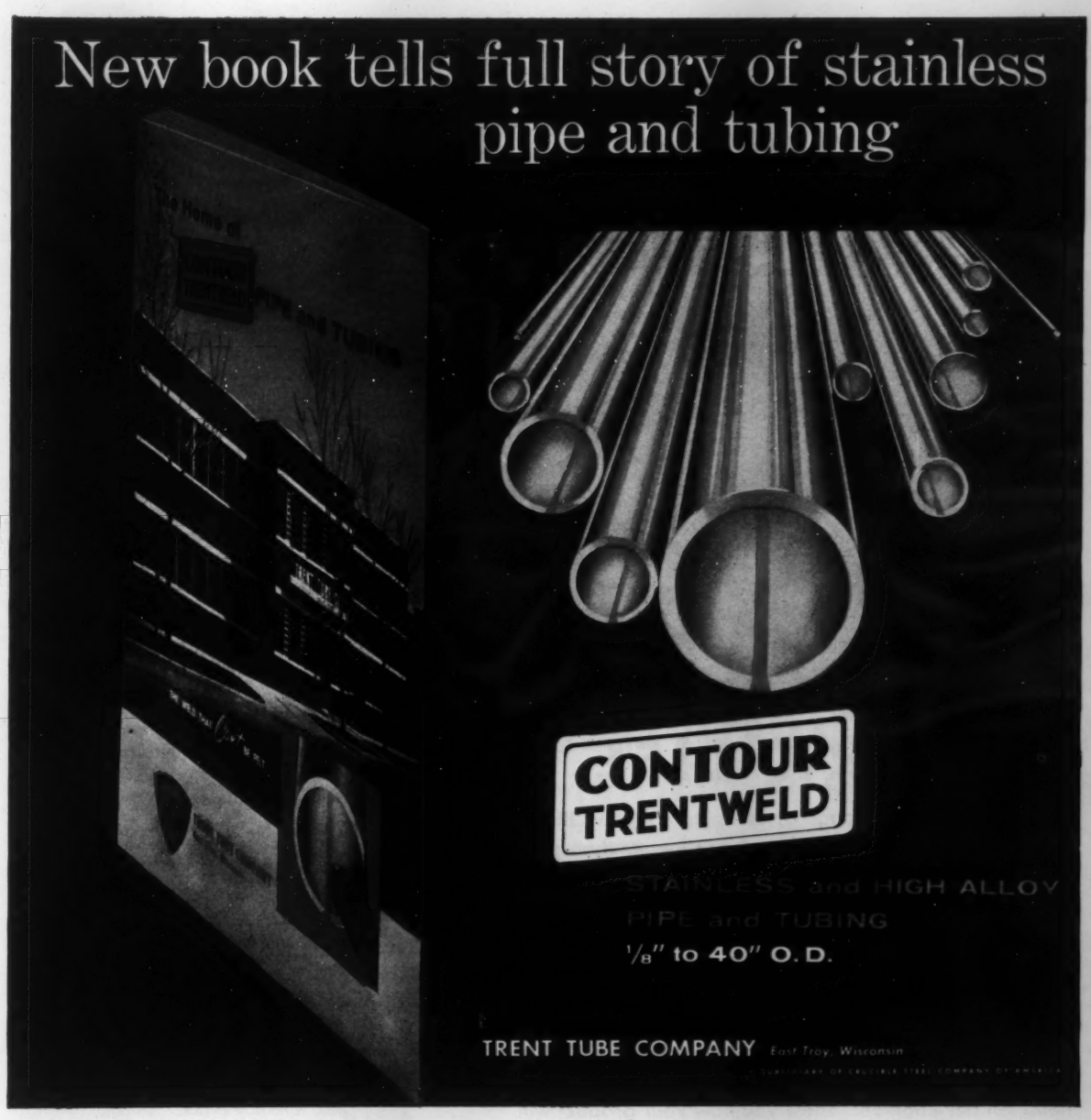
Circle 667 on page 19

Miniature Potentiometer

has molded resistance elements

Type AS molded-composition potentiometer has a diameter of ½-

New book tells full story of stainless pipe and tubing



If you use stainless or high alloy pipe or tubing, this new illustrated handbook was written for you. It's 58 pages big — packed with informative data that you'll refer to again and again.

The table of contents is too long to list here, but it includes, for example, analysis and conversion tables, corrosion characteristics, weights, alloy properties, bending, joining and installation hints.

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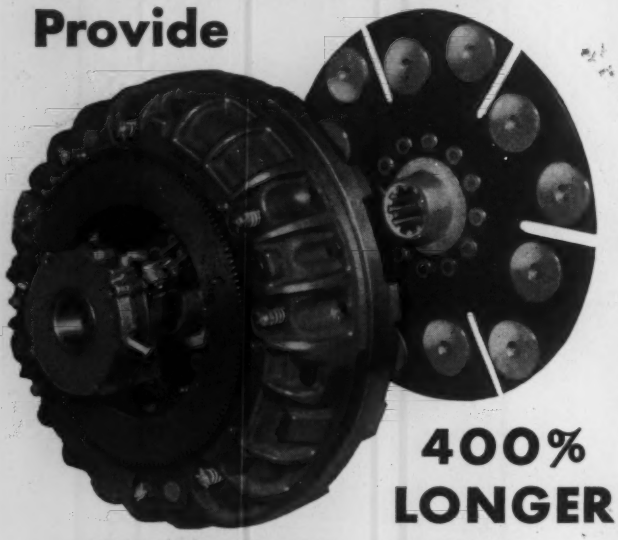
ROCKFORD

MORLIFE® Over-Center CLUTCHES Provide



400% LONGER WORK LIFE

Reports from a wide range of users state that MORLIFE clutches serve from four to ten times longer than previous types of friction clutches using organic facing materials. Adjustments and plate replacements have been reduced to one-tenth those required by previous clutches. The longer on-the-job hours and increased pay loads which MORLIFE clutches make possible furnish a competitive advantage for machines in which these NEW clutches are used. Increased clutch life results in decreased operation cost of vehicles or equipment. Let our engineers show you how *your* product will benefit through using MORLIFE clutches.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

Small Spring Loaded

Automotive Spring Loaded

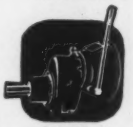
Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs



Speed Reducers

ENGINEERING B-W PRODUCTION

CLUTCHES

New Parts

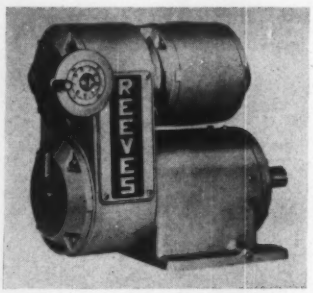
in., and is rated at 0.5-w continuous duty. Thick, solid, molded resistance elements provide large factor of safety. Unit is available in linear taper with locking-type, screwdriver-slotted shaft. It is dust-tight, splashproof and fungus-resistant. Available in 15 resistance values from 100 ohms to 5.0 megohms, potentiometer meets applicable military specifications. **Ohmite Mfg. Co.,** 3630 Howard St., Skokie, Ill.

Circle 668 on page 19

Variable-Speed Drives

for 1 to 5-hp applications

Two sizes of Vari-Speed Motodrives have a wide range of assembly combinations to fit variations in size, shape and orientation of space available for installation. New disc assemblies permit wider out-



put speed ranges. Drives are for 1 to 5-hp applications. **Reeves Pulley Co.,** Div. Reliance Electric & Engineering Co., 1225 Seventh St., Columbus, Ind.

Circle 669 on page 19

Liquid-Tight Connector

accommodates conduit in sizes ⅜ to 1¼ in.

Liquid-tight connector joins flexible and rigid conduits. Incorporating a female hub, connector is tightened on threaded end of rigid conduit, while liquid-tight conduit end is installed as a standard liquid-tight connector. Integral,

Circle 495 on page 19

Circle 496 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 42

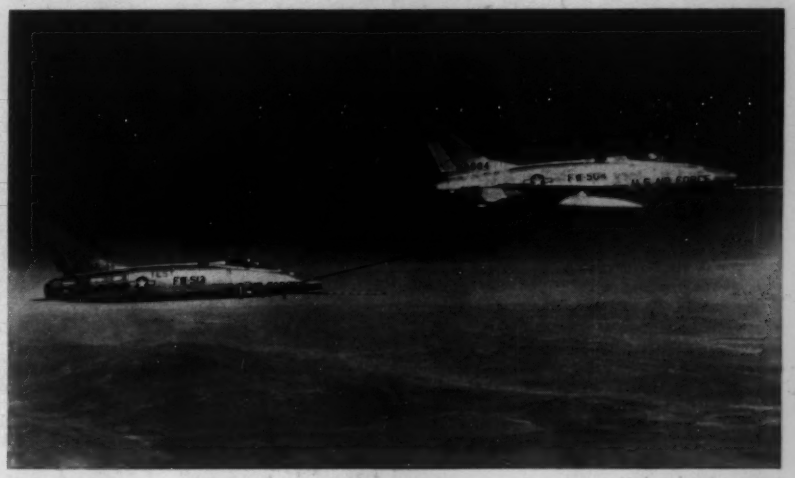
New, Stronger Silicone Rubber Now More Readily Available

The toughest and strongest heat-stable silicone rubber ever developed is rapidly becoming more available thanks to new production techniques. Introduced in March, 1957, as Silastic* 916, this new Dow Corning silicone rubber combines mechanical strength and abrasion resistance approaching that of conventional organic rubber with the thermal stability and high dielectric properties characteristic of silicone rubber.

Useful over a temperature span ranging from —130 to over 500 F, Silastic 916 is ideally suited for a wide variety of sealing and gasketing applications previously considered "borderline" for silicone rubber. Known applications where Silastic 916 has proved particularly useful range from oven door gaskets to aircraft door seals — from wire and cable insulation to oxygen mask components.

Typical properties for parts made from Silastic 916 include tensile strength in the range of 1500 psi . . . a 50% increase. Tear strength is approximately 200 ppi . . . an increase of 100%. Elongation is over 500% and hardness is from 50 to 60 on the Shore A scale. Silastic 916 also shows excellent resistance to compression set after prolonged exposure to elevated temperatures. (*Cont. Pg. 2*)

*T. M. REG. U. S. PAT. OFF.



SILICONE FLUID INCREASES RELIABILITY OF PLANE-TO-PLANE REFUELING SYSTEM

The exceptional thermal stability of Dow Corning silicone fluids helped Flight Refueling Inc., Baltimore, to engineer greater reliability and maximum simplicity into their highly successful, high-altitude refueling system.

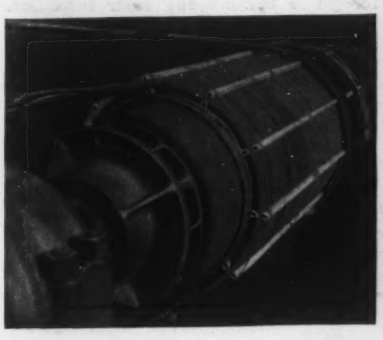
This "probe and drogue" system employs Dow Corning 510 Fluid as the viscous medium in the torque converter used to transfer power from the drive motor to the hose reel. While the hose itself weighs only 300 pounds, it exerts up to 1000 pounds pull due to the high-speed airstream. Another 800-pound pull is required to disconnect the hose when refueling is completed.

Despite heavy loading, a 9½ hp motor is all it takes to pay out hose smoothly at the rate of 5 feet per second, and to retrieve it at twice this speed. That's because the silicone fluid enables the converter to produce maximum torque promptly on demand and keeps the converter serviceable at temperatures down to —65 F. The use of only 5 pints of stable 510 Fluid eliminates the need for mechanical devices to compensate for severe temperature changes.

The "probe and drogue" system is replacing other refueling systems because it's lighter, easier to control, more flexible and can refuel more than one plane at a time. The Navy has standardized on this method for all air-to-air refueling. The Tactical Air Command uses the new system for its KB-50 three-point tankers and for the "Buddy System" where one F-100 refuels another. *No. 426*

New Silicone Insulated Transformers Are Light-Weight, Maintenance Free

Added proof that you get "more power per pound" and maximum reliability with silicone electrical insulation is provided by Moloney Electric Company's new line of 3-phase, nitrogen filled, dry-type transformers.



Take the 1500 KVA rating, for example: these units weigh only 21,000 pounds and measure less than 9½ x 5½ x 10 feet. Silicone-insulated throughout, they can be safely installed almost anywhere regardless of high ambients, contaminated or dust laden atmospheres. In addition, these transformers are virtually maintenance-free; no liquids to maintain, no toxic fumes to guard against.

Contributing to the transformers' efficient performance are the strong, lightweight silicone-glass spacer bars laminated by Formica Company into U-shapes for maximum heat dissipation. Moloney (*Cont. Pg. 2*)

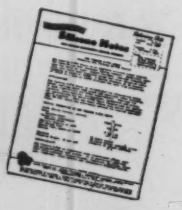
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



New Reference to Silicone Fluids describes the Dow Corning silicone fluids specified for most industrial and military applications. This convenient four page reference lists typical applications, and physical and electrical properties for each fluid — from flash point to volume resistivity. A useful and compact data source designed to help you select the silicone fluid most suitable for any specific application. *No. 430*

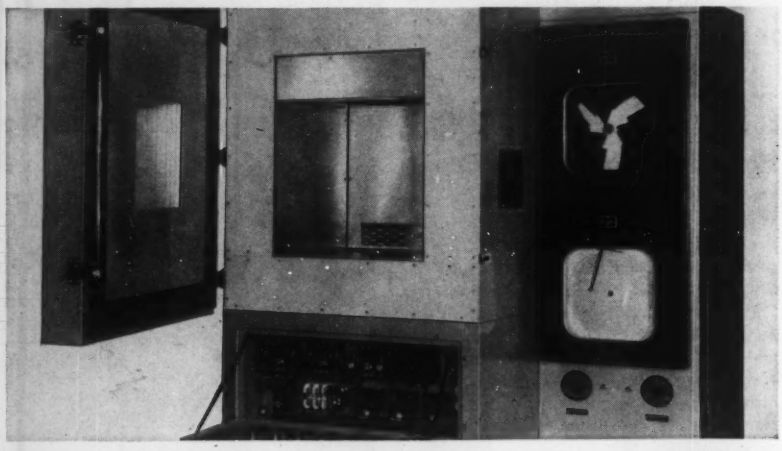
Silicone Rubber That Vulcanizes At Room Temperature — that's new SILASTIC RTV 501. Has good shelf life before catalyzing, longer working time after catalyzing. Two fluid components, mixed together, vulcanize over a period of 24 hours to form a 30 durometer rubber serviceable from —70 to 500 F. *No. 431*

Silicone Insulated Motors Last Longer — Cost Less. A new brochure bears out this fact with numerous case histories of motors operated for years under adverse conditions in many different industries. An illustrated booklet, it's sure to suggest ways in which you can use silicone insulation rewinds to obtain low-cost protection against overloads, high ambient temperatures, rapid reversing, moisture and corrosion. *No. 432*

Silastic, An Ideal Dielectric Material, has high dielectric strength, high thermal conductivity, great resistance to weathering, corona, arcing, ozone, and electrical and mechanical fatigue. And it remains serviceable from —130 to 500 F. A new brochure describes how these properties can help you. *No. 433*

New Flexible Silicone Resin, Dow Corning 808 is used to formulate heat resistant, high gloss decorative finishes for space heaters, incinerators, clothes driers, stoves, and other appliances. Dow Corning 808 Resin shows excellent color retention, gloss retention, and adhesion up to 500 F. For more information, circle *No. 434*

Silicone Bearing Grease, Dow Corning 44, provides long-time lubrication of ball bearings operating from —40 to 400 F. A new brochure includes description of properties and case histories which show that 44 Grease helps cut maintenance costs by lubricating where petroleum greases quickly fail. *No. 435*



Silicone-Glass Laminates Prove Utility In Extreme Temperature Test Chambers

Relatively unaffected by extreme temperatures, silicone-glass laminates have proven ideal as insulating and structural materials in the thermal test chambers produced by Trop-Arctic, Inc. of Muncie, Indiana.

Bonded with Dow Corning silicone resins, the laminated glass terminal strips retain exceptionally high strength and are dimensionally stable at all temperatures encountered during testing. Trop-Arctic's Model STA-FB-4-2-2, shown above, utilizes upwards of 10 square feet of quarter-inch laminate panels. Three 1-inch silicone-glass tubes in the chamber wall protect the thermocouples, interior wiring and fan motor shaft. Silicone-glass laminate is also used to frame the observation window.

Trop-Arctic's thermal test chambers, producing controlled temperatures ranging from —100 to 350 F, are designed for use in the material test laboratories of large aircraft companies. It takes the automatic programmer less than 40 minutes to switch the 4-cubic-foot chamber from one temperature extreme to the other.

According to Trop-Arctic, silicone-glass laminates proved the most practical insulating and structural materials because of their superior "moisture resistance, dimensional stability, tensile and flexural strength, thermal characteristics, chemical resistance, and appearance." *No. 427*

NEW, STRONGER SILICONE RUBBER *(Cont.)*

Silastic 916 is also non-toxic, serviceable at extreme low temperatures and easily processed. It does not "nerve up," but can be milled and compounded after shelf-aging almost indefinitely. Suitable for molding, extruding or calendering, it can be hot-air vulcanized. It has considerably more "green strength" than previous silicone rubbers making fabrication techniques even more similar to those for organic rubbers. *No. 428*

MAINTENANCE-FREE TRANSFORMERS *(Cont.)*

also uses Formica's G-54 silicone-glass for phase barriers and layer insulation.

To complete this all-silicone insulating system, assembled cores and coils are impregnated with Dow Corning 997 Varnish; lead wires are covered with Silastic,* the Dow Corning silicone rubber. *No. 429*

*T. M. REG. U. S. PAT. OFF.

Dow Corning Corporation, Dept. 6821, Midland, Michigan

Please send me: 426 427 428 429 430 431 432 433 434 435

NAME _____

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COMPANY _____

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first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

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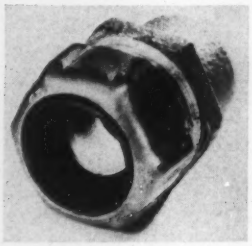
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

threadless grounding cone accommodates any flexible-conduit spiral, permitting installation without disassembly. Built-in nylon ring provides seal. Female hub connector is available in straight de-



sign to accommodate all conduit in sizes ⅜ to 1¼ in. **Thomas & Betts Co.**, 36 Butler St., Elizabeth, N. J.

Circle 670 on page 19

Centrifugal Pump

handles molten metals

Model 9025-M vertical centrifugal pump handles molten metals such as solder, tin, zinc and lead at temperatures to 700 F. Three aluminum cooling fans, which rotate simultaneously with one-piece extended stainless-steel shaft, provide safe operating temperature. Unit is available with either ¼-hp, 1140-rpm or ¾-hp, 1725-rpm insulated

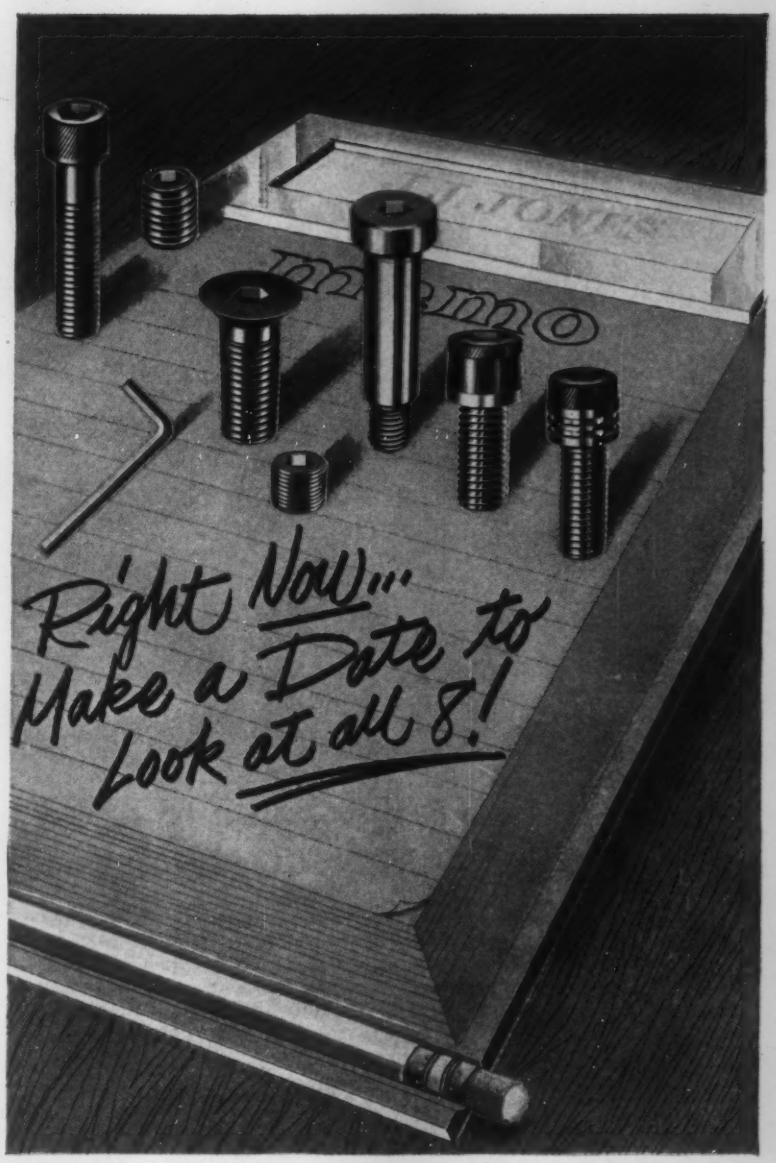
motor, for capacities to 7 gpm and heads to 8 ft. **Ruthman Machinery Co.**, 1811 Reading Rd., Cincinnati 2, Ohio.

Circle 671 on page 19

Rotary Actuator

has low input torque requirements

Integral servo valve rotary actuator has output torques from 7500 to 360,000 lb-in. at 1000 psi. Low input torque remains constant at varying supply pressures, while



Blue Devil SOCKET SCREW PRODUCTS

MEMBER ASMMA

A broad line and a complete line, Blue Devil Socket Screws have the variety to meet just about all your socket requirements. Better check with your nearby Blue Devil distributor... see how he can help you out!

Actual cross-section diagram shows how cold forming of Blue Devil Socket head insures unimpaired fiber continuity.

Sold only through Authorized Industrial Distributors

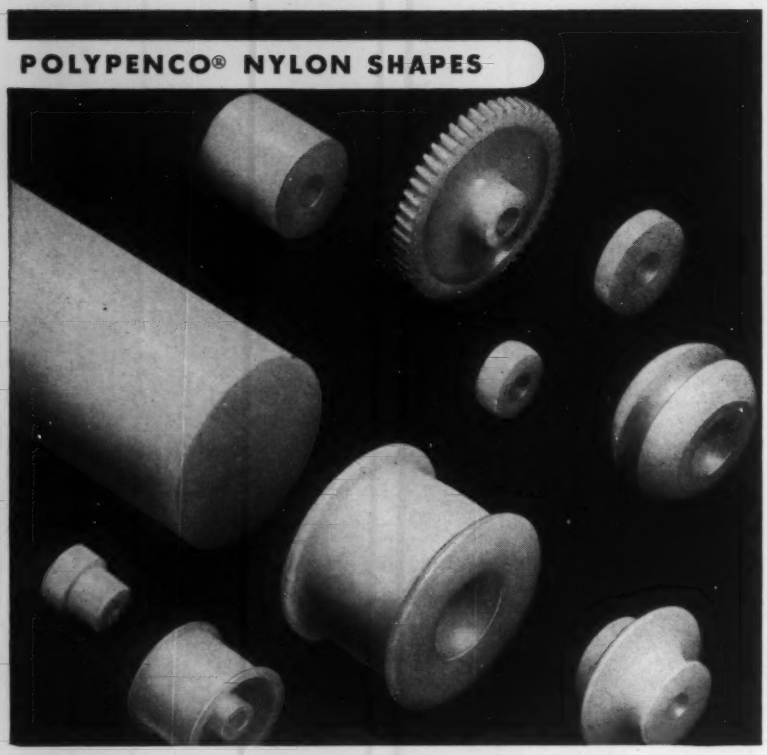
SAFETY SOCKET SCREW CO

6510 North Avondale Avenue • Chicago 31, Illinois

Warehouses at: Los Angeles, San Francisco, Detroit, New Haven, New York City

SOCKET SCREWS EXCLUSIVELY!

Circle 497 on page 19



Practical, low-cost solution to nylon parts design: POLYPENCO Nylon Rod

ADAPTABLE Polypenco Nylon rod continues to be the choice of designers who require highest quality nylon *plus* rapid, low-cost production. From the complete range of sizes of Polypenco Nylon rod, it's a quick and economical step to fabricate close tolerance parts and components on standard metalworking tools. Bearings, rollers, thick gears and other parts machined from Polypenco rod have these outstanding properties:

- **Wear resistance**
- **Resilience**
- **Excellent strength to weight ratio**
- **Low coefficient of friction**
- **Noise dampening**
- **Non-galling and non-abrasive to other materials**
- **Chemical resistance**
- **Good electrical insulating properties**

Polypenco Nylon stock shapes are also available in tubular bar, strip, tubing and plate and can be shipped immediately from warehouses located throughout the country. For fabrication of parts, The Polymer Corporation of Pa. maintains a special fabricating service. Write for data on products or services.

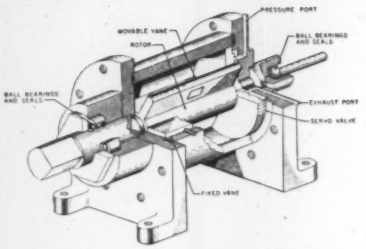
THE POLYMER CORPORATION OF PENNA.
Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon-† NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

New Parts

output varies directly with pressure. Torque multiplication ratio can be as high as 1500:1. Speed of response is 3 seconds per stroke at flows from 8 to 60 gpm. Unit consists of a rotating input shaft



coupled to a slide-type valve, and a rotating output shaft attached to a set of movable vanes. All seals are Teflon. Six sizes are available with diameters from 4 to 12 in. and heights from 2½ to 13 in. **Industrial Control Products Inc.,** 4 Clinton Rd., Caldwell, N. J.

Circle 672 on page 19

Teflon Tape

in ten colors for application coding

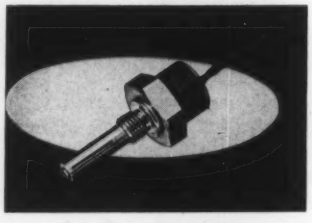
Polypenco Teflon tape, in thicknesses of 0.001 through 0.125 in., is available in ten colors for application coding and identification. Colors meet NEMA and MIL-STD-104 requirements. Service temperature range is −320 to 500 F. Tape has zero water absorption and is chemically inert. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa.

Circle 673 on page 19

Temperature Probe

is ceramic-coated, variable-resistance unit

Model 49132 variable-resistance immersion probe measures temperatures from −350 to 800 F. Probe resists abrasion and environmental stresses in air or fluids. It



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Consult an Ortman-Miller representative regarding your pneumatic and hydraulic problems. His broad experience with standard and special cylinder applications is available to you without cost or obligation. Use convenient coupon for name and address of O-M representative nearest you.

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133 Sidney Street, Cambridge 39, Mass.

Circle 500 on page 19

New Parts

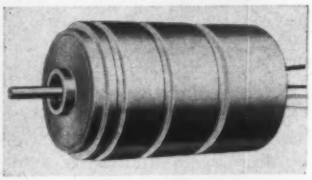
is AN threaded for insertion into tapped holes. Tested to withstand pressures higher than 3000 psi, probe is suitable for applications such as measuring jet engine inlet temperatures. Construction consists of a thin-walled stainless steel tubular form, coated with ceramic and wound with pure platinum wire. **G. M. Giannini & Co. Inc.**, 918 E. Green St., Pasadena 1, Calif.

Circle 674 on page 19

Stepping Motor

translates pulses to incremental shaft positions

Uses of this Syncramental bidirectional stepping motor include rotation of potentiometers, counters, rotary switches and control mechanisms. Unit translates pulses to incremental shaft positions. Shaft



is indexed by a magnetic clutch which rotates with energized armature to which it has been magnetically attracted. Angular increment per pulse is 36 deg in either direction at maximum stepping rate of 15 deg per second. Starting-torque load capacity is 2 lb-in. at 20 C. Temperature range is −55 to 120 C at altitudes to 90,000 ft. **G. H. Leland Inc.**, 123 Webster St., Dayton 2, Ohio.

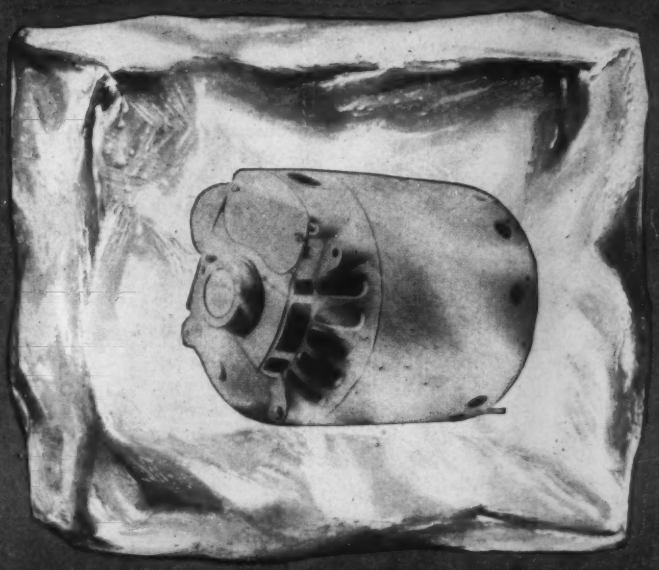
Circle 675 on page 19

Long-Frame Switch

for communication equipment

T-Switch is available in two frame designs for communication equipment, especially switchboard applications. Series 11000 is a push-button switch with momentary action, push-to-lock, pull-to-release action, or locking type. Series 11200, a two-position turnbutton switch, is available with nonlocking or locking action. Long springs without forms at point of flexing provide long spring life. Springs and pressure plate are spring-tempered nickel silver or nickel-plated

Need a COOL motor



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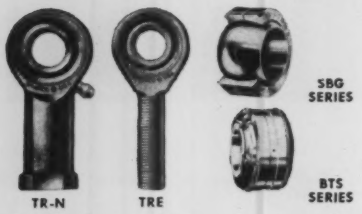

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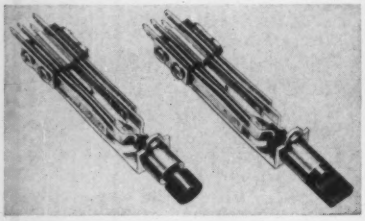
Circle 502 on page 19

New Parts



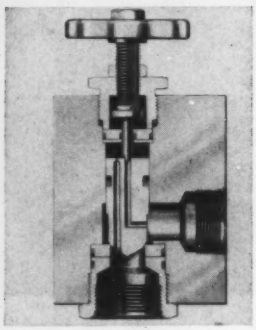
phosphor bronze. Solder lugs are hot tin dipped. **Switchcraft Inc.**, 1328 N. Halsted St., Chicago 22, Ill.

Circle 676 on page 19

Throttling Valve

uses pilot needle to control 5000-psi pressures

Throttle-Flo valve is available in 1-in. size for use with pressures to 5000 psi. Pilot needle valve is easily adjusted to obtain proper flow, giving full flow in two and one-half turns. Metering is accurate to 1/100 gpm through entire range of valve. Body is aluminum alloy, with stem, inserted



seat and piston of hardened stainless steel. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 11, Ohio.

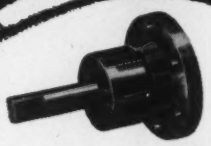
Circle 677 on page 19

Neutron Detector Tubes

for reactor control and monitoring systems

Model VXN-1 is an enriched boron trifluoride proportional tube for counting thermal neutrons. It is available in 1, 2 and 2 1/16 in. diameters of various active lengths. Nominal operating voltage is 1700 v with 250-minimum plateau having typical slope of 2 per cent per 100 v. Model VXN-2 is of the recoil type. It has a polyethylene

VIKING PUMPS any way you want them

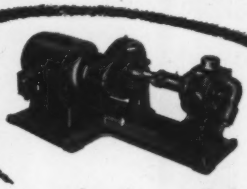


stripped models

The internal working parts of original "Gear-within-a-gear" Viking pumps are available to fit into your integral casing. Conserves space, piping arrangement, drive equipment, etc. Available in 2/3, 1½, 3½, 5, 10, 18 GPM and larger. Positive, self-priming, capable of handling all types of liquids up to several hundred pounds discharge pressure, in many models.

custom models

No matter how you wish to apply the positive self-priming Viking pump, it can be custom built in the size and casing design to fit your piping and drive arrangement. Thousands of individual problems have been successfully answered with specially designed Viking "Gear-within-a-gear" pumps.



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Pick any standard Viking pump in 21 sizes from 2/3 to 1050 GPM, in many types of mounting and drive arrangements. They are available from over 750 cataloged models.

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Circle 503 on page 19

AVOID the **HIGH COST** and difficulty of fabricating long, hard & straight parts by conventional methods . . .

THOMSON

60 Case

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

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TYPICAL *60 Case* PARTS

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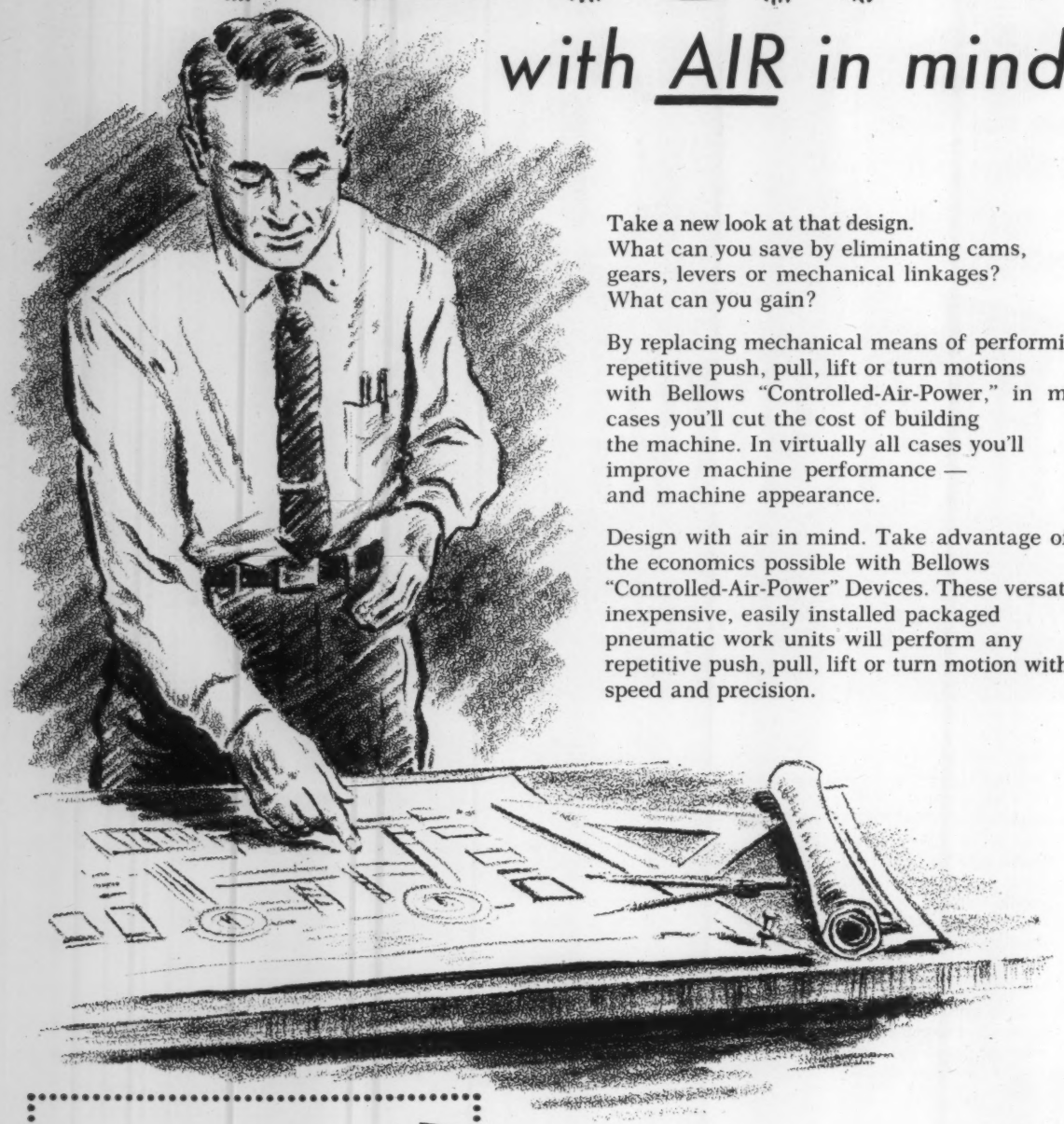
THOMSON INDUSTRIES, Inc.
Dept. C-5, Manhasset, New York

Circle 504 on page 19

DESIGN

with AIR in mind



Take a new look at that design. What can you save by eliminating cams, gears, levers or mechanical linkages? What can you gain?

By replacing mechanical means of performing repetitive push, pull, lift or turn motions with Bellows "Controlled-Air-Power," in most cases you'll cut the cost of building the machine. In virtually all cases you'll improve machine performance — and machine appearance.

Design with air in mind. Take advantage of the economics possible with Bellows "Controlled-Air-Power" Devices. These versatile, inexpensive, easily installed packaged pneumatic work units will perform any repetitive push, pull, lift or turn motion with speed and precision.

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The Bellows Co.. Akron 9, Ohio

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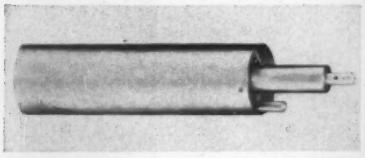
inner wall and ethylene filling, and counts fast neutrons. Nominal operating voltage is 1575 v. Both tubes are for reactor control and



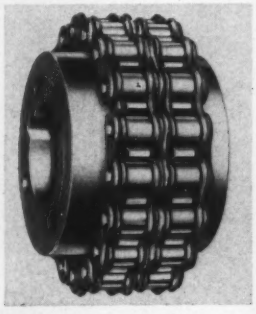
reactor monitoring systems. **Victoreen Instrument Co.**, 5806 Hough Ave., Cleveland 3, Ohio.

Circle 678 on page 19

Flexible Shaft Couplings

have interchangeable taper bushings

Steel roller-chain shaft couplings are available with interchangeable taper bushings having bores in increments of 1/16-in. for all standard shaft diameters. Couplings are easily installed on shafts, and absorb moderate end play and misalignment. They can be coupled



and uncoupled by removal of a roller-chain connecting pin. **Diamond Chain Co. Inc.**, Dept. 435, 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 679 on page 19

Universal Power Module

is fully transistorized

Universal power module meets many applicable MIL specifications by incorporating transistors and eliminating vacuum tubes. Input can vary from 50 to 400 cycles, making unit applicable for field or airborne power-supply applications. Improved amplifier design gives increased operational freedom from hum and noise. Stand-

(*Please turn to Page* 180)

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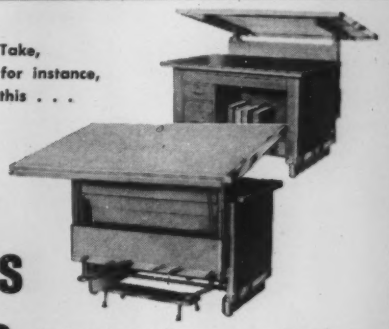

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Circle 506 on page 19

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You Get Uniform Quality In Accordance With Your Needs . . . Because Claymont's operations are fully integrated, we are able to exercise rigid quality controls throughout every single stage of production and fabrication to assure that customer specifications will be met.

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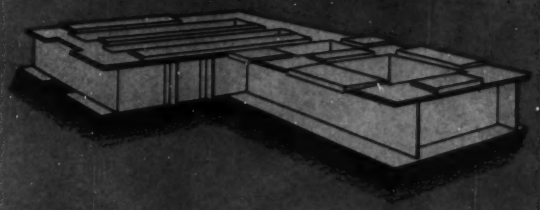
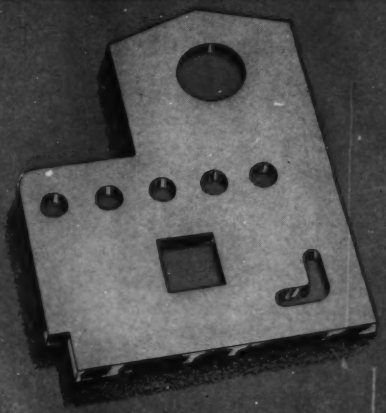
4936

dependable source
Steel Parts

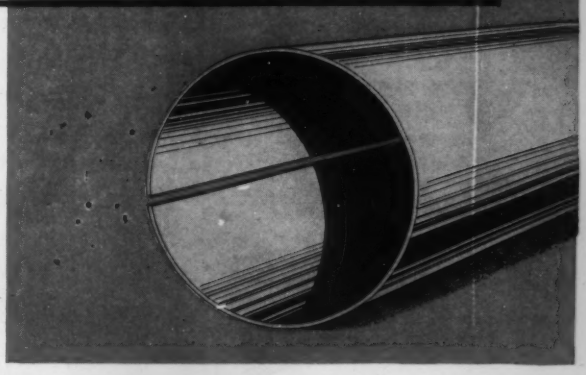
Production Weldments—Many production component parts for which castings are presently being used can be safely and profitably replaced by weldments. The advantages: cost savings plus reduction in weight with no loss in strength. Claymont is completely equipped to produce weldments in many sizes and shapes, and from a wide variety of steels.



Flame-Cut Patterns—Claymont has multiple-torch travagraphs for producing large quantities of irregular shapes that exceed the gage or size limitations of blanking presses; and single-torch, semi-automatic radiagraphs for cutting straight cuts and simple patterns, circles and smaller-quantity jobs. A special type of radiagraph is used to prepare edges prior to welding.



Heavy-Duty Plate Forming—Claymont's heavy-duty mechanical pressing, bending, and shaping equipment is capable of a wide variety of forming operations on heavy steel plate.



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Circle 508 on page 19

How Alcoa Aluminum Fasteners make good awnings even better

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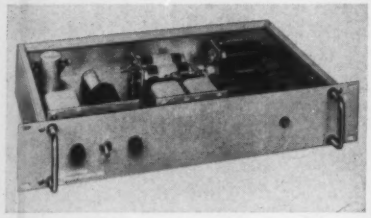
Circle 509 on page 19

New Parts

(Continued from Page 177)



ard 3½ x 19 x 12-in. rack and panel fits all racks. Front and rear-panel connectors provide flexibility in rack applications. **Electro Instruments Inc.**, 3794 Rosecrans, San Diego, Calif.

Circle 680 on page 19

Overlay Felt

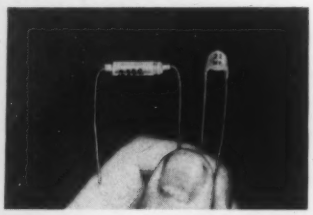
of Dynel acrylic fiber

Feutron mechanically interlocked felt is for use as overlay material to improve performance properties of low-pressure reinforced plastic-laminate structures. Material is fabricated from Dynel acrylic fiber. It has high resistance to a wide range of chemicals and corrosive materials, and provides a fiber-free, smooth surface. Surface also has good ultraviolet ray resistance, giving entire laminate improved resistance to sun exposure. Felts are available in widths to 80 in., lengths of 60 yd or multiples, and in weights as low as 2 oz per sq yd. **American Felt Co.**, Glenville Rd., Glenville, Conn.

Circle 681 on page 19

Disc Capacitor

miniature unit has low power factor



Miniature disc capacitor, designated Ultra-Kap, meets small size, high-capacitance requirements of transistor circuitry in bypass and coupling applications. Unit has low power factor. **Globe-Union Inc.**, Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis.

Circle 682 on page 19

Do You Have A Deburring Headache?

GET THE FACTS ABOUT

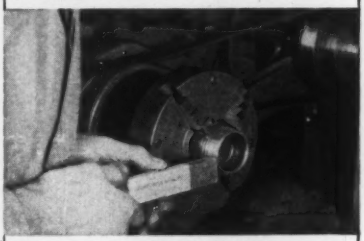
CRATEX
RUBBERIZED ABRASIVES

"The World's Best For Industrial Use"

Exceptionally superior and unparalleled for:

DEBURRING, SMOOTHING, CLEANING and POLISHING operations after dimensional shaping

For removing rust, heat-marks, tarnish, fatigue lines, scratches, excess solder, corrosion and other surface defects: for blending-in polishing welded seams, final sharpening and polishing to lustre-like finish.



CRATEX IS MADE IN FOUR DIFFERENT GRITS
Coarse Grit to Extra Fine in
WHEELS · POINTS · BLOCKS STICKS · CONES
For Machine or Manual Application on the broadest range of
Hard and Soft METALS and other Materials

Backed by over 30 years industrial, professional and technical application, CRATEX Rubberized Abrasives are widely used nationally and in foreign countries. Made from "premium quality chemical rubber bonds" pressure-molded into uniform textures without hard or soft spots—resilient to absorb shock—ready for instant use—offer uniform controlled "cushioned action" with ease of manipulation for dimensional accuracy, without loss of tolerances.

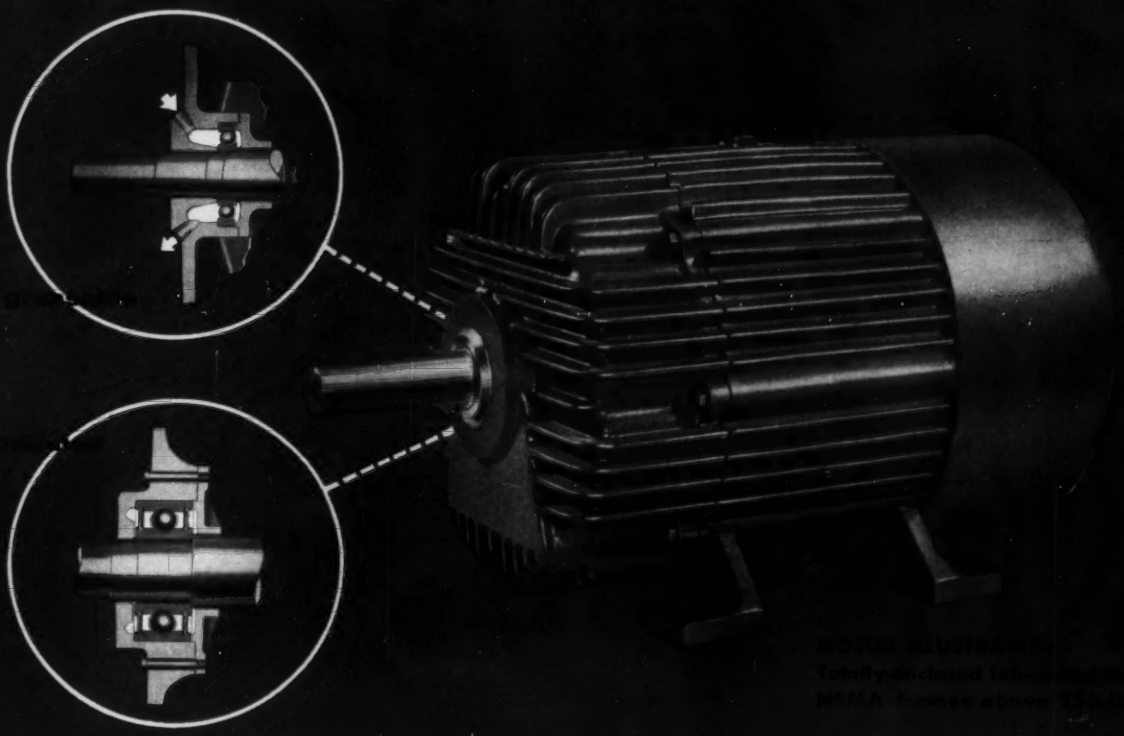
OPERATE SAFELY, EFFECTIVELY AT SPEEDS UP TO 5,500 S.F.P.M.

Send for comprehensive illustrated catalog—learn how CRATEX Rubberized Abrasives can cut your costs, speed production and insure quality results. Sold at leading industrial supply dealers.

CRATEX MANUFACTURING CO.
81 Natoma St., San Francisco 5, Calif.

Circle 510 on page 19

YOUR CHOICE of motor bearings . . .



—when you specify ELLIOTT Crocker-Wheeler Type N integral horsepower motors

Whatever your operating conditions or maintenance practice, Crocker-Wheeler offers the motor bearing best adapted to your needs or preference.

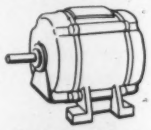
The Open Greasable type
requires only infrequent lubrication. All old grease is positively flushed out, eliminating risk of forcing grease into motor interior. An external grease reservoir helps seal and protect the bearing. The inner cap and grease reservoir prevent rust or corrosion from within.

Prelubricated bearings
are furnished for applications requiring operation without regular service lubrication. They are sealed cartridge-type, factory grease-filled, with inner protective cap.

Choice of bearings
is another design feature of the new Elliott Type N motor line. These motors are honestly new—inside and out. We think you'll agree that they incorporate every important feature that distinguishes a modern motor.

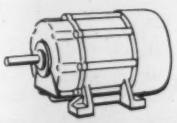
W7-1

OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated

Dripproof Protected



Totally-enclosed, fan-cooled Frames 256 U and smaller

ELLIOTT Company

CROCKER-WHEELER DIVISION

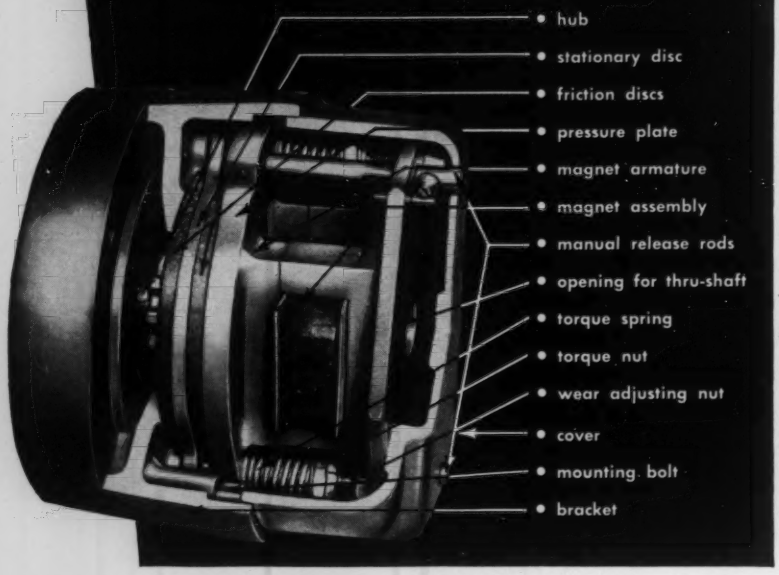
Jeannette, Pennsylvania

We will be glad to send a copy of this new booklet describing the complete line of Elliott C-W type N motors. Ask for Bulletin PB 6000-6.

Circle 511 on page 19

COMPARISON PROVES

DINGS *direct-acting*
MAGNETIC DISC BRAKES
are your best buy!



COMPARE these outstanding advantages

- Direct-acting for positive, instantaneous stops
- Thru-Shaft design to solve installation problems
- Accommodate standard NEMA shaft extensions
- Designed for mounting on all old and new re-rated NEMA type "C" motor flanges
- Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment
- Fail-safe design in event of power failure
- Simple design and rugged, compact construction

COMPARE for operating and maintenance economy

- No mechanical linkages or levers to maintain
- No solenoids required
- No need for auxiliary fuses, rectifiers, rheostats, auxiliary relays or extra wiring

NEW DINGS EXPLOSION-PROOF MAGNETIC DISC BRAKES
UL approved for hazardous locations

Now Dings combines all the advantages of direct-acting magnetic disc brakes with explosion-proof features tested and approved by Underwriters Laboratories . . . the "707" Series for Class I, Group D hazardous locations, and the "709" Series for Class I, Group C and D and Class II, Groups E, F, G.

Always specify Dings Brakes from your regular motor supplier, or ask about Dings complete engineering service for your brake problems.

DB157⅔

d.b

DINGS BRAKES, INC.
A Subsidiary of Dings Magnetic Separator Co.
4714 W. ELECTRIC AVE. • MILWAUKEE 46, WISCONSIN

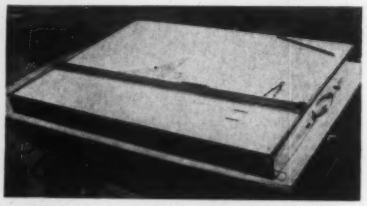
ENGINEERING DEPARTMENT

EQUIPMENT

Tracing Board

is large, illuminated unit

Fluorescent - illuminated tracing board is 3 by 4 ft in size, yet is light and thin enough to be portable. It is equipped with string-



type parallel rule, Plexiglas top, built-in straight edge and adjustable back legs. **Porta-Trace Inc.**, 342 Clinton St., Binghamton, N. Y.

Circle 683 on page 19

Printed Tapes

are available in nine patterns

Patterns are printed in red on Mylar self-sticking tape which reproduces photographically. Material is particularly useful in making blueprints and whiteprints. Film is a dimensionally stable, high-strength, nonbrittle tape which will not break or tear. It is extremely thin and has a strong, long-lasting, clear adhesive. Tape is available in nine patterns, all in six standard widths from 1/32 to 1 in. It does not require a separating liner. **American Chart Service Inc.**, 101-103 Dover St., Somerville 44, Mass.

Circle 684 on page 19

Ultrasonic Probes

have range of 2 kc to 2 mc

Glennite ultrasonic probes check and calibrate ultrasonic equipment, and measure and control ultrasonic intensity levels or beam uniformity. Two models are available, one calibrated at 500 kc and the

Design "Low Cost" Into YOUR Equipment

GITS

World's Largest Selection of Low-Cost Lubricating Devices

LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

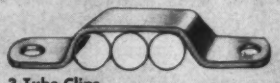
Special Introductory Price
Just **$14.95** F.O.B. Factory
Satisfaction or your money back

CLIPS FOR ATTACHING TUBING

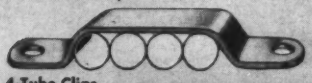
When ordering, specify ¼", 5/16" or ⅜" tubes. Style TF.

Single Clips

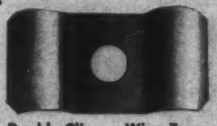
Double Clips



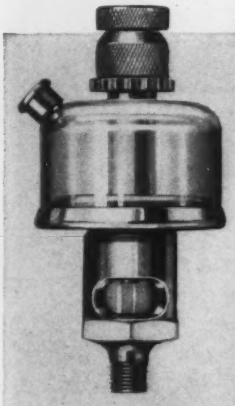
3-Tube Clips



4-Tube Clips

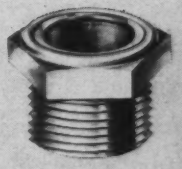


Double Clips — Wing Type



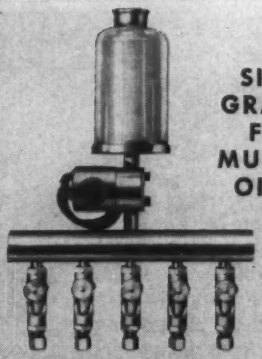
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.



GEAR CASE GAUGES

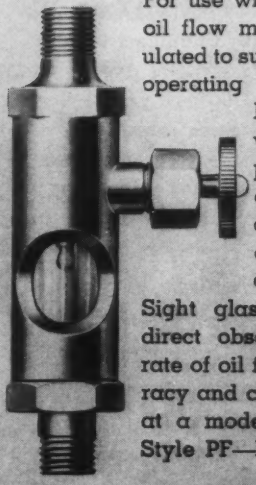
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

The Standard For Industry For Almost Half A Century

1868-C South Kilbourn Avenue
Chicago 23, Illinois

Clip this page for handy "rough reference"

Circle 513 on page 19

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both ends of circuit—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for Steam, Oxygen, Acetylene, etc.

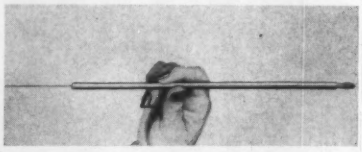
REPRESENTATIVES IN PRINCIPAL CITIES

SINCE 1915 ® QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

Engineering Equipment



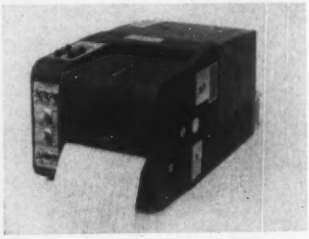
other at five points: 40, 300, 500 and 700 kc, and 1 mc, to accuracy of ± 2 db. Both models are equipped with subminiature connectors and cables for direct reading through standard laboratory voltmeters. **Gulton Industries,** 212 Durham Ave., Metuchen, N. J.

Circle 685 on page 19

Recording Oscillograph

writes at speeds over 30,000 ips

Available in two sizes, this recording oscillograph produces dry, self-developing records, without chemicals, within seconds after recording. It offers up to 36 or 50 channels of information, gives legible records dc to above 3000 cps, and writes at speeds above 30,000 ips. Unit processes 7 or 12-in. width records. Timing lines and



record numbering are provided. **Midwestern Instruments,** Tulsa, Okla.

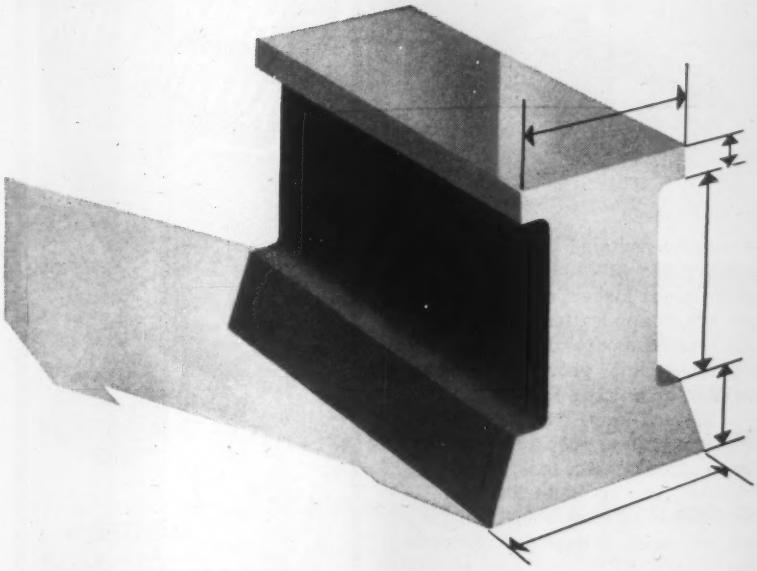
Circle 686 on page 19

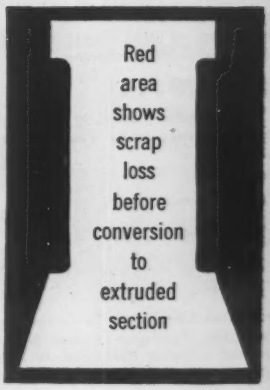
Erasing Machine

is lightweight electrical unit

Sovereign electric erasing machine permits fast erasing with minimum fatigue. It operates cool under heavy work conditions, has minimum torque and automatic stall control to protect drawings against damage from heavy pressure. Lightweight and easy to handle, unit incorporates pushbutton control, hollow shaft which permits use of 7-in. eraser, and octagonally shaped motor housing

Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section





This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 410, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin STEEL ... a great name in steel

Circle 515 on page 19

GEAR-GRIP

The most revolutionary Flexible Coupling Design Development in a century!

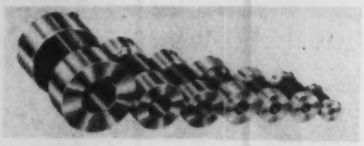
Now available for sub-fractional, fractional and integral H. P.

Ability of rubber Flex-Element to float between captive and fittings distributing load similar to universal joint action

- Load Ranges—1/12 H.P. through 30 H.P.
- Shaft Sizes—1/8 through 1-7/8.
- Specified exact length to design requirements per series.
- Prevention of end thrust among many other design advancements.

Dyna-Line . . .

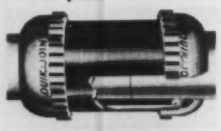
The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Lengths varied to design specifications in each series.
- Load ranges—1/15 to 1½ H.P.
- Shaft sizes—3/16" to ¾".

Quik-Joint Steel Compression Pipe Fittings

- UL approved for hazardous fluids.
- Guaranteed for 2000 p.s.i.
- Allows 7° angular deflection.
- No threading of pipe required.
- Special Silicone Gasket for Steam applications.



Write for Catalogs and Technical Bulletins.

Guardian
PRODUCTS CORP.
COUPLING DIVISION
Dept. M-957
Michigan City, Indiana

Circle 516 on page 19

Engineering Equipment

to prevent machine from rolling off drafting table. Unit is furnished with five assorted 7-in. erasers and extra heavy-duty electric cord. **Frederick Post Co.**, 3650 N. Avondale Ave., Chicago 18, Ill.

Circle 687 on page 19

Variable Transformer

is portable unit for low-power use

Powerstat portable variable transformer No. 2PF10 is suited for laboratory, inspection, classroom and other applications where current requirements do not exceed 1 amp. Unit provides a light, variable ac voltage source for zero to 132-v, 1-amp, 132 va output from a 120-v, 60-cycle, single-phase input. Six-foot cord-plug provides two receptacles and 1-amp, 125-v ac fuse housed in plug end of cord. **Superior Electric Co.**, Dept. PF10, 83 Laurel St., Bristol, Conn.

Circle 688 on page 19

Tracing Paper and Cloth

has nonreproducible cross-section lines

Grid-X tracing paper and cloth is printed with nonreproducible lavender cross-section guide lines which speed and improve head lettering, ruling, measuring and scaling on original drawings. Grid-X is printed on both transparentized rag tracing paper, which accepts both pencil and ink, and on water-repellent tracing cloth impervious to perspiration stains. Cloth can be cleaned with common solvents. Paper is available in sheets, pads and rolls in standard widths, lengths and variety of cross-sections. Cloth is available in roll form only. **Charles Bruning Co. Inc.**, 4700 Montrose Ave., Chicago 41, Ill.

Circle 689 on page 19

MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

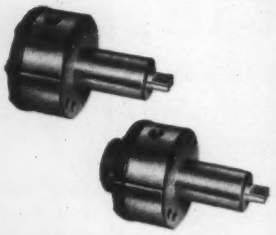
1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

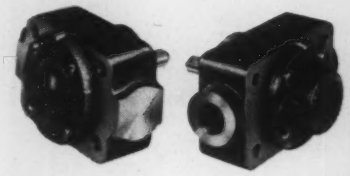
Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 517 on page 19

NOW! Have Reliable Lubrication at Minimum Cost

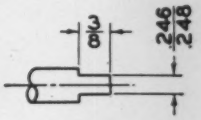


Models LF and RF
Capacities 55-170 g.p.h. at 1800 r.p.m.
Designed for flange mounting without shaft seal; with *choice* of internal or external porting. Model RF has automatic reversing feature which permits driving the pump in either direction... without changing direction of flow or port positions.

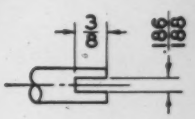


Models LFD and RFD
Capacities 60-180 g.p.h. at 1800 r.p.m.
Designed for non-directional service; for flange mounting with internal porting. Variations for external porting and/or shaft seal are shown below. Model RFD has the automatic reversing feature which permits driving the pump in either direction... without changing direction of flow or port positions.

ALTERNATE SHAFT DRIVE ENDS
For All Models



MODIFICATION "A"



MODIFICATION "B"

Tuthill "Cartridge-Type" Pumps Solve This Problem for Plant Maintenance...and Original Equipment Manufacturing

Durable—Reliable—and Available from Stock!

1. The demand for minimum cost lubrication pumps without sacrifice in performance, durability and reliability is *ideally* satisfied by the TUTHILL series of Models LF, RF, LFD and RFD *cartridge-type* pumps.

2. TUTHILL "cartridge" pumps get their reputation as cost-savers from their special design for original equipment use, their durable construction, their reliability...and the fact that they are *available from stock*. Note their compact size as shown in the photos above. Consider how all waste space has been eliminated for more adaptability. Think how they can be easily applied to your *own* requirements...in your plant...or in your equipment manufacturing plans.

3. These variables are available:

a. Pumps with...*or without*...automatic reversing performance

b. Pumps with...*or without*...a shaft seal

c. Pumps with internal...*or external*...porting

d. Pumps with *variations* of both internal and external porting

4. TUTHILL Catalog Section 108 contains line drawings showing each model in detail, shaft rotation and porting arrangements and other vital statistics to help you select the RIGHT model. Fill out the attached coupon—or write.

TUTHILL PUMP COMPANY
953 E. 95th Street, Chicago 19, Illinois

Gentlemen:

☐ Please send me Catalog Section #108
☐ Please send the complete catalog on the Tuthill line
☐ Have your representative call

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Circle 518 on page 19

On North American's F-100 Super Sabre...

Delron Fasco SPACERS

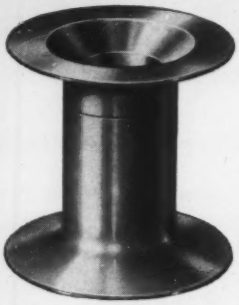
SAVE WEIGHT & INSTALLATION TIME!

Backbone of our nation's air superiority, F-100 Super Sabre is the first supersonic fighter-bomber to go into mass production.

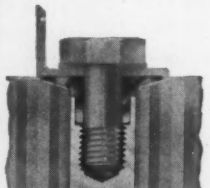
North American's advanced engineering research is constantly developing new techniques for honeycomb panel construction and fastening methods.

On the F-100, FASCO Spacers provide a lighter-weight, more economical method of attaching structure and equipment to honeycomb panels. Simple, two-piece design and easy installation with ordinary tools, make FASCO Spacers the best bet for efficient honeycomb panel fastening.

Write for engineering information about this and other applications of FASCO Spacers which may help solve your critical fastening problems!



Lightweight, high column strength aluminum or stainless steel FASCO Spacers are available in a variety of designs.



FASCO Threaded Self-Locking Spacer is specified for honeycomb panels of North American's F-100 Super Sabre.

This is another example of how Delron Products solve the critical fastening problems of industry!

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THE ENGINEER'S Library

Recent Books

Mathematics Refresher for Professional Engineers' and Land Surveyors' License. *By John D. Constance, P.E.; 52 pages, 8½ by 11 in., paperbound; available from John D. Constance, P.E., 625 Hudson Terrace, Cliffside Park, N. J.; $2.00 per copy.*

This book is intended as the basis for a review course for the mathematics portion of state license examination for professional engineer and land surveyor. Problems are complete with solutions, and are based on a sampling of many states' examinations.

A Management Guide to Electronic Computers. *By William D. Bell, Consultant for Mellonics, Van Nuys, Calif., 402 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$6.50 postpaid.*

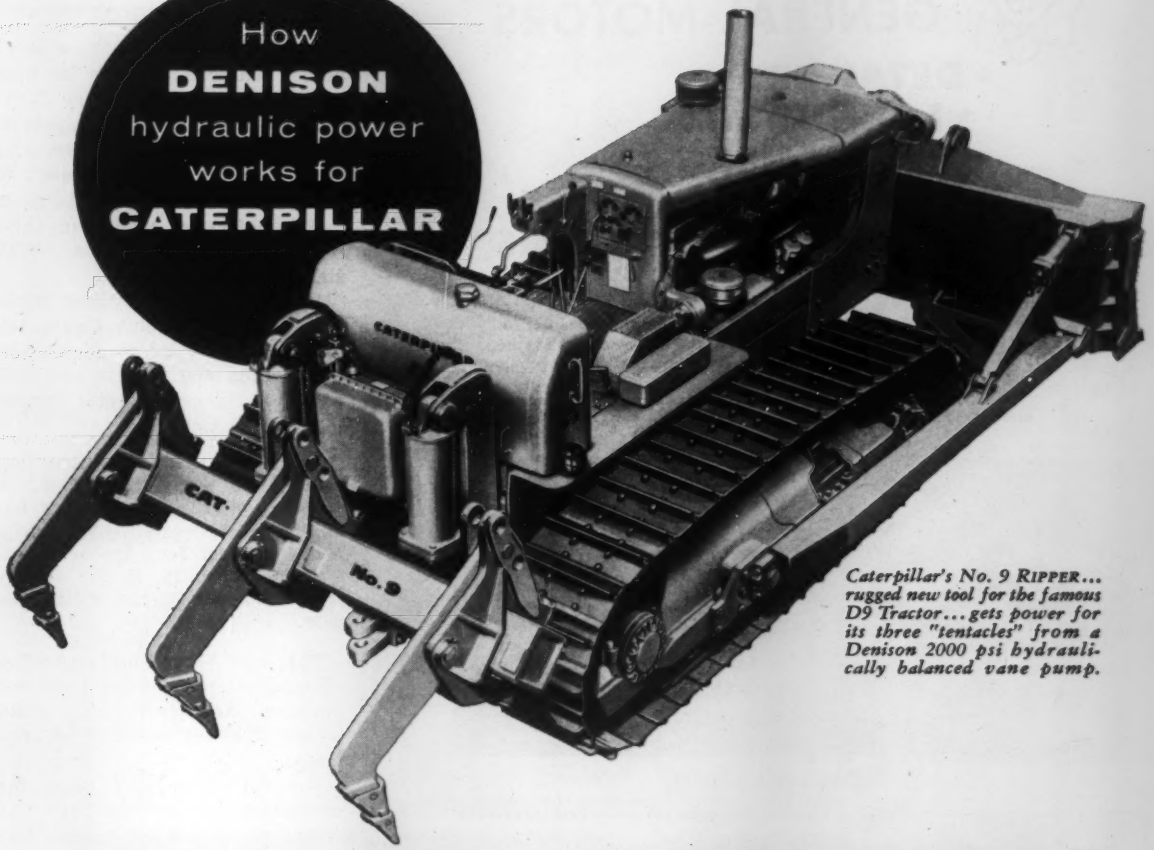
This book explains in nontechnical language what computers are for, what the equipment is and how it works, what results and problems the machines bring, how to find if such a system is needed, how to justify it, how to choose and install a system, and actual experiences of many other companies with electronic data-processing.

Standard Handbook for Electrical Engineers. *Edited by Archer E. Knowlton, Consulting Editor,* Electrical World. *2311 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$19.50 postpaid.*

This standard reference in the electrical engineering field provides on-the-job information in the form of facts, figures, definitions, conversion factors, physical and mathematical principles, accepted formulas, experimental data, etc.

In this ninth edition, every sec-

How **DENISON** hydraulic power works for **CATERPILLAR**



Caterpillar's No. 9 RIPPER... rugged new tool for the famous D9 Tractor... gets power for its three "tentacles" from a Denison 2000 psi hydraulically balanced vane pump.

PUTTING TEETH IN THE "RIPPER"

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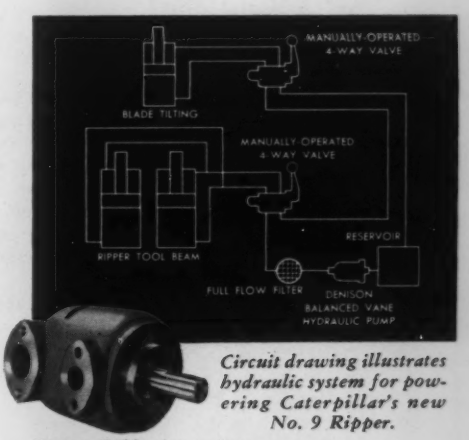
Caterpillar's rugged No. 9 Ripper—newest tool designed for their powerful D9 Tractor—proves again the basic design advantages of Denison's 2000 psi vane-type hydraulic pump.

The Ripper's three working shanks are powered by the Denison "T" series pump—capable of delivering up to 2000 psi continuously. Driven by the engine power take-off, the Ripper's pump actually operates at 1450 psi (relief valve setting) which provides generous reserve stamina to withstand heavy workloads with no danger of breakdown. With the Denison "T" series pump, Caterpillar designers assured the owner of cold-weather pump-starting ability without damage to the pumps. They assured speedy servicing in the field because the complete pumping cartridge is removable as a unit. It all adds up to *lower operating cost* and dependable performance.

There's less weight, less cost-per-horsepower—with smaller lines and valves with the Denison 2000 psi pump as the heart of a hydraulic system. Design flexibility is unlimited.

Have your Denison hydraulic specialist tell you more about the 2000 psi pump—and help you with any equipment or machinery design problem. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

DESIGNERS—ENGINEERS! New Bulletin 201 describes "How to Design More Efficient Hydraulic Power Into Mobile Machinery." Write us.



Circuit drawing illustrates hydraulic system for powering Caterpillar's new No. 9 Ripper.

Denison 2000 psi vane-type hydraulic pump.

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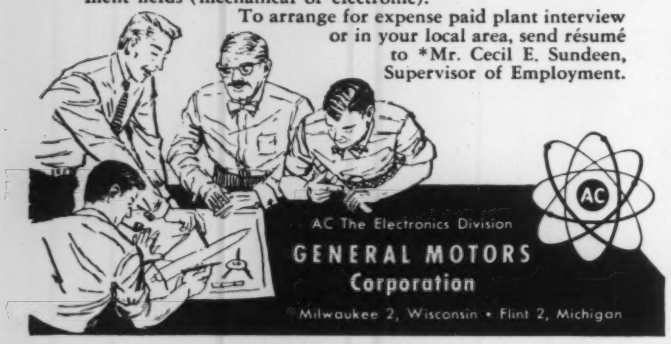

Circle 521 on page 19

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tion has been revised. New or extended material includes the transistor, nuclear power, new dielectrics for capacitors, new synthetic resins and plastics, detailed properties, electrical measurement for automation, new lighting, recent metals, electric conductor tables recast on basis of new ASTM standards.

Also included are power cables, highest transmission voltages, telemetering, new international electrical units and values, and magnetic amplifiers in motor control.

Unit Operations of Chemical Engineering. *By Warren L. McCabe and Julian C. Smith; 945 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$10.50 postpaid.*

This text covers unit operations of chemical engineering from both practical and theoretical standpoints at a uniform level of treatment.

General discussions cover fluid mechanics, flow of heat, and mass transfer. Approach to the basic operation of fluid flow differs from conventional treatments. Specifically, boundary layer concept is introduced early and used throughout the chapter as a basic idea tying together fluid flow through pipes and fluid flow around single solids, through orifices, past sudden contractions and enlargements, and through beds of solids.

Theory of diffusion is based on the relative velocity method and the problem of direction of diffusion, and number of diffusing components are handled in a simplified and general manner.

Elements of Partial Differential Equations. *By Ian N. Sneddon, Professor of Mathematics, University of Glasgow; 327 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book presents the theory of partial differential equations in a form suitable for those whose main interest lies in finding solutions of particular equations rath-

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Continuing stress

Gas leakage

Rough handling in use

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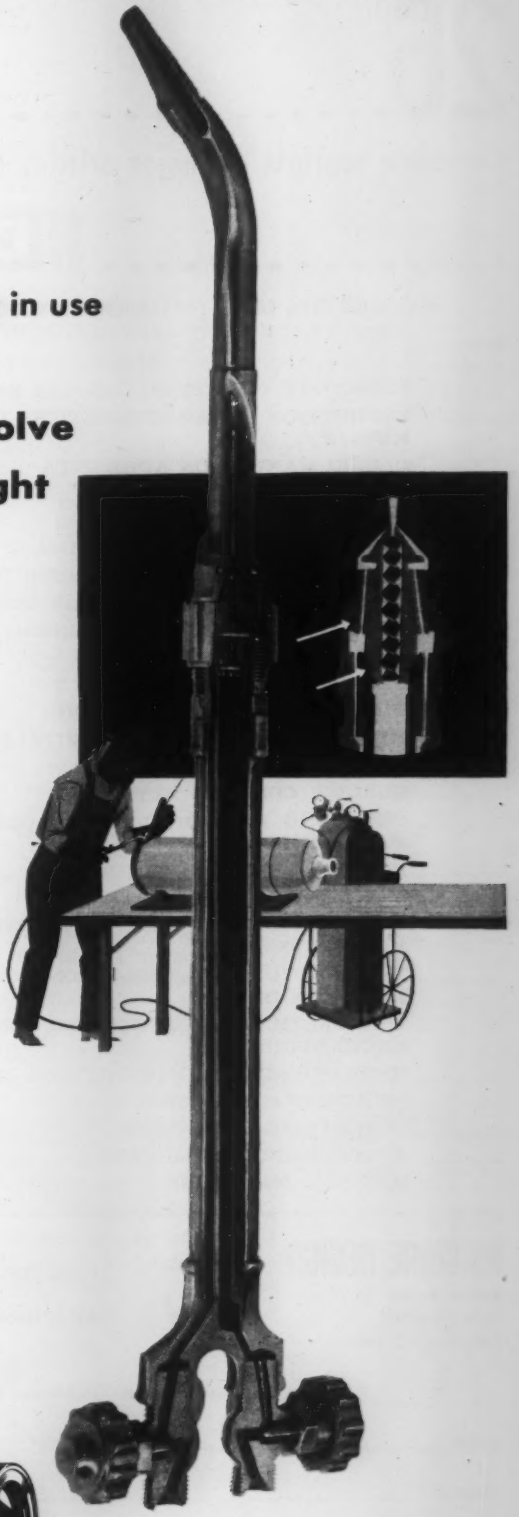

As static seals, commercial Buna N O-rings performed satisfactorily in Victor welding torches — *when the rings were new.*

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Circle 523 on page 19

26

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er than in general theory.

The first chapter is devoted to ordinary differential equations in several variables and Caratheodory's theorem in foundations of thermodynamics. In the second chapter, an account is given of first-order equations, in particular, equations of mathematical physics: Laplace's and Poisson's equations, the wave equation, Maxwell's equations, and diffusion equation.

Although treatment includes a logical development of theory, emphasis is on numerous applications of equations to solution of a wide variety of problems in physics and engineering. The entire field of partial differential equations is covered, with modern techniques introduced as they arise naturally.

Association Publications

Proceedings of the Second RETMA Symposium on Applied Reliability. *93 pages, 8½ by 11 in., paperbound; published by and available from Engineering Publishers, GPO Box 1151, New York 1, N.Y.;* $5.00 *per copy.*

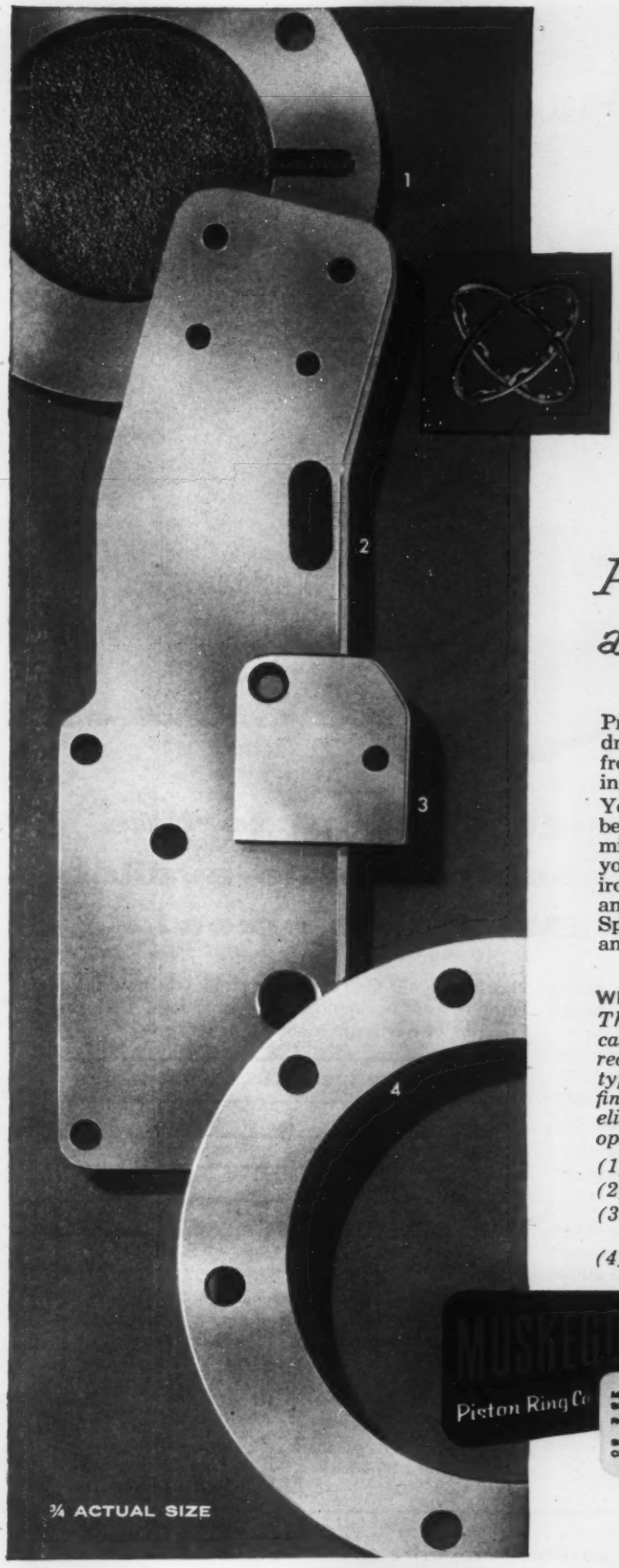
This book contains 14 illustrated papers which were presented at the Second Radio-Electronics-Television Manufacturers Association Symposium on Applied Reliability in June, 1957.

Major sections cover selection and use of components in design, principles and techniques of mechanical design, industry vs. military responsibility in contract and specifications, measurement of design, case histories of equipment and systems.

Correction: Following are the correct prices for books reviewed in The Engineer's Library, MACHINE DESIGN, August 8, 1957.

Transistor Circuit Engineering. *Edited by Richard F. Shea, General Electric Co.; available from* MACHINE DESIGN; **$12.00** *postpaid.*

Technical Data on Plastics. *Available from Manufacturing Chemists Association,* 1625 *Eye St., N.W., Washington* 6, *D. C.;* **$3.25** *per copy.*



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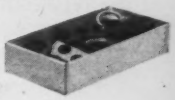

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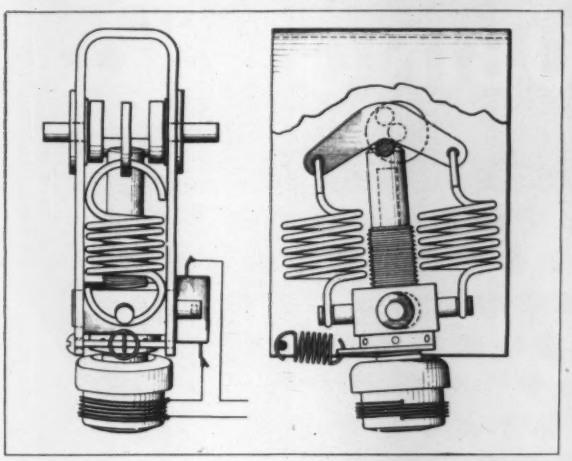
Circle 525 on page 19

NOTEWORTHY

Patents

Heat Motor

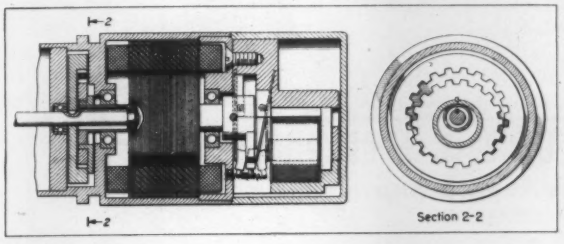
Controlled thermal expansion of a low melting point wax provides the driving force in an overload-protected heat motor. Melted by an electrical resistance coil (lower right), the wax undergoes a large volume expansion during the change of phase from solid to



liquid. Resulting linear movement of a piston is converted to a high-torque oscillating motion by a spring-return crankshaft and trunnion arrangement. Overload damage to the heat motor—for example, due to jamming of the driven mechanism—is prevented by a switch which de-energizes the heater when loads become too high. *Patent* 2,797,546 *assigned to Dole Valve Co. by Mullapudi M. Reddi.*

Incremental Motor

Electrical pulses are converted to one-turn rotation by an incremental motor designed for pulse-initiated switching or control operations. Sign of the input pulse (plus or minus) determines direction of output-shaft rotation. Regardless of the duration or magnitude of the pulse, the motor shaft rotates through exactly one turn, returning precisely to the starting position. Backlash or bounce of the differential-type gearing is extremely small. Shown here with a split-



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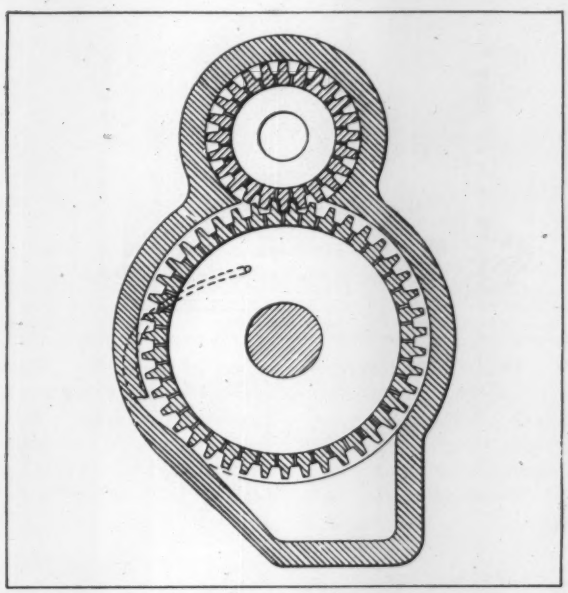
Circle 527 on page 19

field driving motor, the basic mechanism can be incorporated in almost any type ac or dc motor. *Patent* 2,797,786 *assigned to Viking Industries Inc. by Homer A. Engle and Howard M. Greene.*

Self-Lubricating Gears

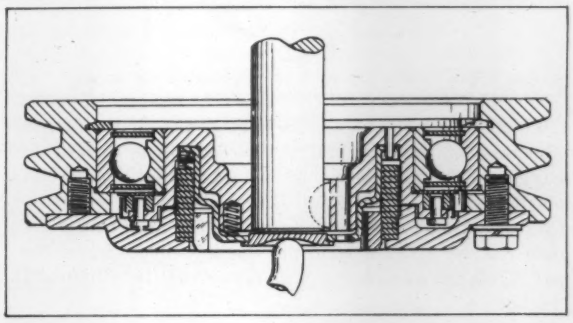
Centrifugal circulation of lubricant through radial holes extending to the gear-teeth bottom lands dissipates heat in a self-lubricating gear assembly. Hol-



low interiors of the gears form lubricant reservoirs, and gear rotation keeps lubricant around the reservoir perimeter. Full supply of lubricant to the reservoirs is provided by a surrounding housing and integral sump. Typical use is a high-speed turbine-drive transmission. *Patent* 2,781,105 *assigned to Thompson Products Inc. by Robert Cliborn.*

Helical-Spring Clutch

Centrifugally actuated pawls holds a helical-spring clutch in tight engagement despite high-speed load fluctuations or torque reversals. Effect is to protect clutch frictional surfaces from damage. Pawls retract when clutch speed drops to a safe value, thereby allowing external engagement and disengagement of



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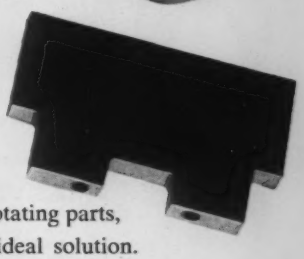

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Circle 528 on page 19

Firing area experiments at Yucca Flat, Nevada Test Site, using anchored balloon as detonation platform for full scale nuclear tests. (USAEC photograph)

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Circle 529 on page 19

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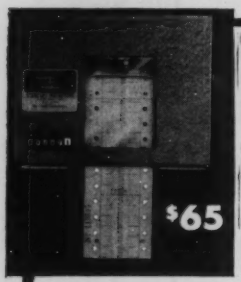

Modern plant operation demands the most efficient and accurate means of evaluating both machine and man-power production . . . that's why leading companies everywhere are equipping their production lines, processes, systems and office machines with Time Recorder-Totalizers.

The Time Recorder-Totalizer monitors the operation of any machine, process or system by chronologically recording the time and duration of every "on" and "off" period during each day.

The Time Recorder-Totalizer makes it possible to analyze the efficiency and performance of any type of equipment plus simplifying cost accounting.

The TIME RECORDER-TOTALIZER incorporates the following features:

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VISIT BOOTH 855 AT I.S.A. SHOW

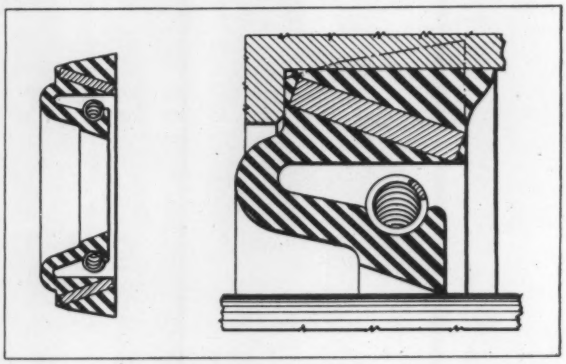
Circle 530 on page 19

Noteworthy Patents

the clutch. *Patent 2,794,524 assigned to Marquette Metal Products Div., Curtiss-Wright Corp. by Columbus R. Sacchini and Donald R. Tomko.*

Radial Seal

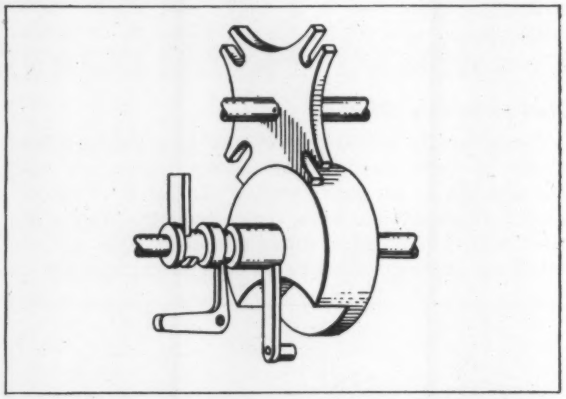
Contact of the outer surface of a garter-spring type radial seal is backed up by the action of an embedded reinforcing member of truncated conical shape. Seal



has shape at left before insertion in the cavity. Enlarged view at right shows compression of the seal elastomer that occurs when the seal is mounted. Result is to give a leak-proof contact between seal and housing over an extended operating life. *Patent 2,797,944 assigned to General Motors Corp. by Ellwood F. Riesing.*

Geneva Mechanism

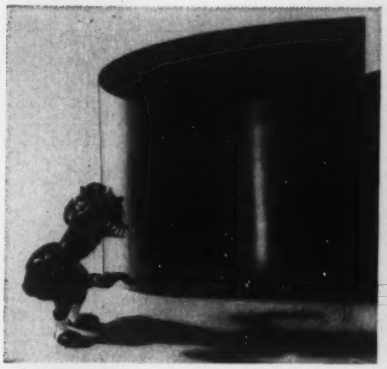
Engagement and disengagement of drive pin and slotted wheel can be externally controlled in a Geneva-type intermittent-motion mechanism. Angular motion of a bell crank moves the input shaft axially, al-



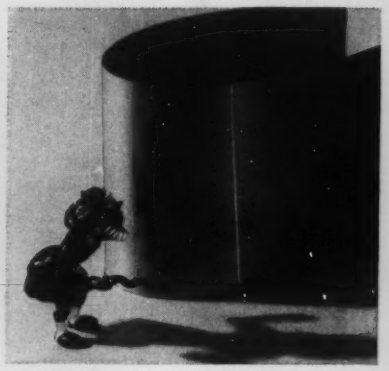
lowing the pin to clear or to engage the Geneva wheel. Clashing of driving and driven elements during engagement is prevented by a contoured groove and mating stop on the input shaft. Shown here with a four-slot Geneva wheel, the selective-engagement feature can be utilized with any Geneva-type drive. *Patent 2,795,150 assigned to Teletype Corp. by Clifford D. Seidler.*

No matter which *FINISH* you like—you can buy it in

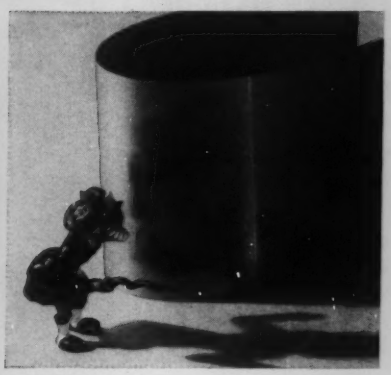
MicroRold® QUALITY STAINLESS STEEL



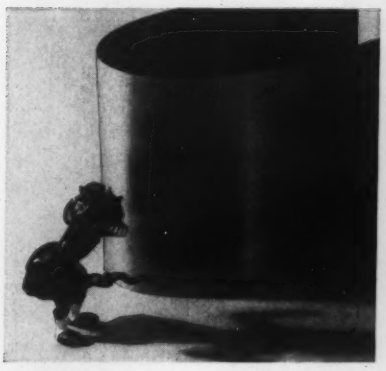
2D—A silvery white, but non-lustrous, surface produced by annealing and pickling cold reduced material. Steel sheets & strip in this condition are most ductile and the surface holds lubricant well for severe drawing operations.



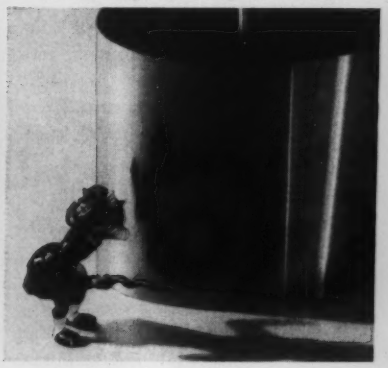
2B—Steel in the 2D condition which is subsequently rolled on a "skin pass" or temper mill. The surface acquires a bright finish from the polished rolls. This surface is somewhat more dense and hard than 2D and is a better starting surface for later finishing and buffing operations.



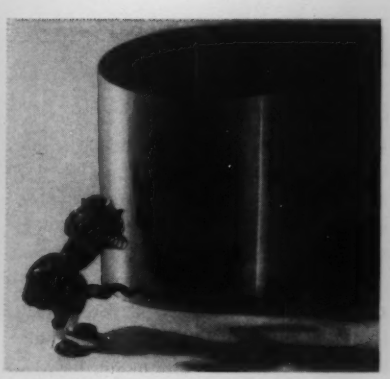
No. 3—This surface is made by grinding with a No. 100 abrasive. This surface is smooth but not as reflective as 2B.



No. 4—A finer finish than No. 3 made by grinding with a No. 150 abrasive. Like No. 3, this surface is easily blended with hand grinders after forming, drawing or welding.



No. 7—Good reflectivity and brilliance made by polishing with a No. 400 abrasive. This semi-mirror finish must be protected during fabrication by adhesive paper or strippable plastics lest the finish be marred beyond repair.



BRIGHT—A highly reflective surface made by cold reducing with highly polished, glass-hard rolls. This finish is only available in Type 430 stainless.

These are our standard surface finishes that are available in types 201, 202, 301, 302, 304 and 430 except Bright which is type 430 exclusively.

These finishes are regularly supplied in sheet and coil form in widths up to 48 inches.

Since Nos. 3, 4, 7 and 430 Bright are smooth reflective surfaces, they are not recommended for severe drawing without special precautions as the mill finish may be marred. Applications such as dairy machinery, kitchen and restaurant equipment and architectural decorative work require only local forming, so these highly polished surfaces are not greatly disturbed. All mill polished sheets are carefully packed to avoid handling imperfections. Protective adhesive paper can be specified by the buyer when needed.

For specific information on recommended surface characteristics for a particular stainless steel sheet and strip application, address your request to our Product Development Dept.

WASHINGTON STEEL CORPORATION — MicroRold — STAINLESS — SHEET & STRIP

Washington Steel *Corporation*

Producers of Stainless Sheet and Strip Exclusively

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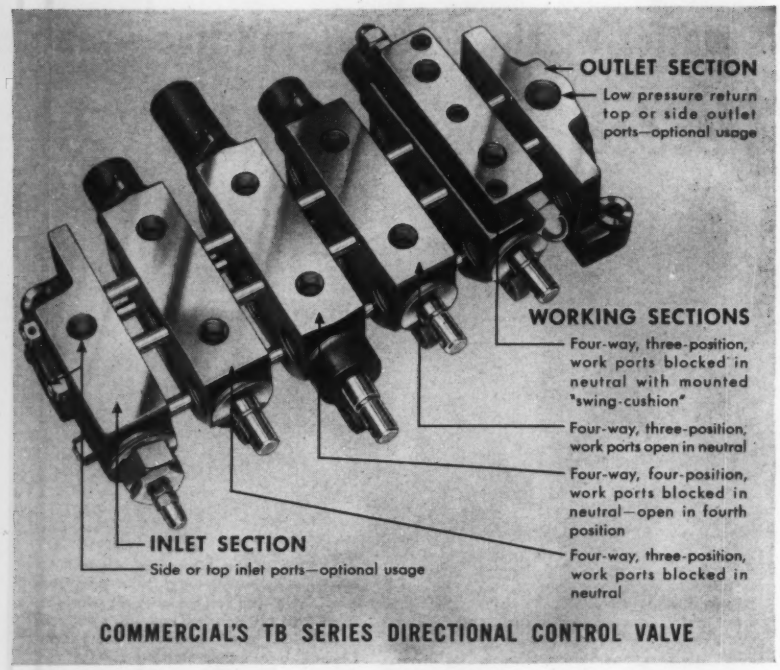
NEW DESIGN IN FLUID POWER CONTROL VALVES


OUTLET SECTION
Low pressure return top or side outlet ports—optional usage
WORKING SECTIONS
Four-way, three-position, work ports blocked in neutral with mounted "swing-cushion"
Four-way, three-position, work ports open in neutral
Four-way, four-position, work ports blocked in neutral—open in fourth position
Four-way, three-position, work ports blocked in neutral
INLET SECTION
Side or top inlet ports—optional usage
COMMERCIAL'S TB SERIES DIRECTIONAL CONTROL VALVE

Pressure Drop Reduced 15%

The higher the back pressure in a control valve the greater the power loss and the less efficient the fluid power system.

Advance design in Commercial's control valves—larger circulatory passageways, more uniform cross sections, smoother wall surfaces, and freedom from abrupt direction changes—lowers internal pressure drop as much as 15%.

Commercial valve performance is increased because flow around large outside surfaces of solid spools is unimpeded—not forced through constricting orifices. And Commercial's valve passageways have equal or greater cross-sectional area than inlet or work ports.

Load Drop Eliminated

Pressurized return flow in many conventional control valves frequently results in erratic operation—sudden movements and one load dropping while another is being positioned.

An individual check, located so as not to cause any passageway constriction, is built into every working section of a Commercial control valve. It blocks all pressurized return flow until it is overcome by pressure build-up from the pump—makes for safe, smooth, precise and accident-free operation.

2000 PSI Operation Perfected

Because of structural design weaknesses in many control valves optimum operation at pressures up to 2000 psi is often not practical or even possible.

With Commercial's control valves operation at pressures up to 2000 psi is recommended. The non-porous grain structure of the high-strength, semi-steel castings used in Commercial's valve sections prevents seepage of pressurized oil. And because of their greater strength the section castings do not distort when stressed under pressure.

The use of O-rings—instead of gaskets—for all sealing between sections and at the ends of spools assures leakproof operation. Elimination of gaskets between sections also precludes overstress and distortion of section castings to prevent possible leakage.

Overload Protection Built In

A combination overload relief-pressure valve—incorporated right in the housing of Commercial's control valves—provides positive safety protection for the fluid power system, plus overload protection for the structural members and tools of the machine in operation. Its complete cartridge construction permits easy removal from the inlet section of the valve bank—for quick inspection or replacement.

Rated on Performance

For the purpose of greater accuracy all Commercial control valves are rated on the basis of performance—not mere size of inlet and outlet ports alone. With Commercial's "performance-rated" control valves proper valve selection for any fluid power system is based on total pressure drop values when assembled in various combinations of actual operating actions.

Commercial's control valves involve parallel circuit operation—provide pressure to two or more operations simultaneously when so desired. Working sections having three-way, three-position; four-way, three-position; and four-way, four-position actions, are available and can be assembled independently in any combination or sequence.

Engineering Help Available

The technical help Commercial sales engineers can offer on the application of Commercial fluid power valves, pumps, motors and cylinders, can easily contribute the kind of fluid power cost savings and improved performance you are looking for and need.

ENGINEERING DATA FREE

For more information write to Dept. S-36, Commercial Shearing and Stamping Company, Youngstown 1, Ohio. For your copies of Commercial's fluid power engineering bulletins just check the items below in which you are interested and attach to your letterhead.

- ☐ "Performance Rated" Valves, Catalog H-12
- ☐ Oil-Hydraulic Pumps and Motors, Catalog H-4
- ☐ Oil-Hydraulic Cylinders, Catalog H-3

COMMERCIAL
shearing and stamping

Circle 532 on page 19

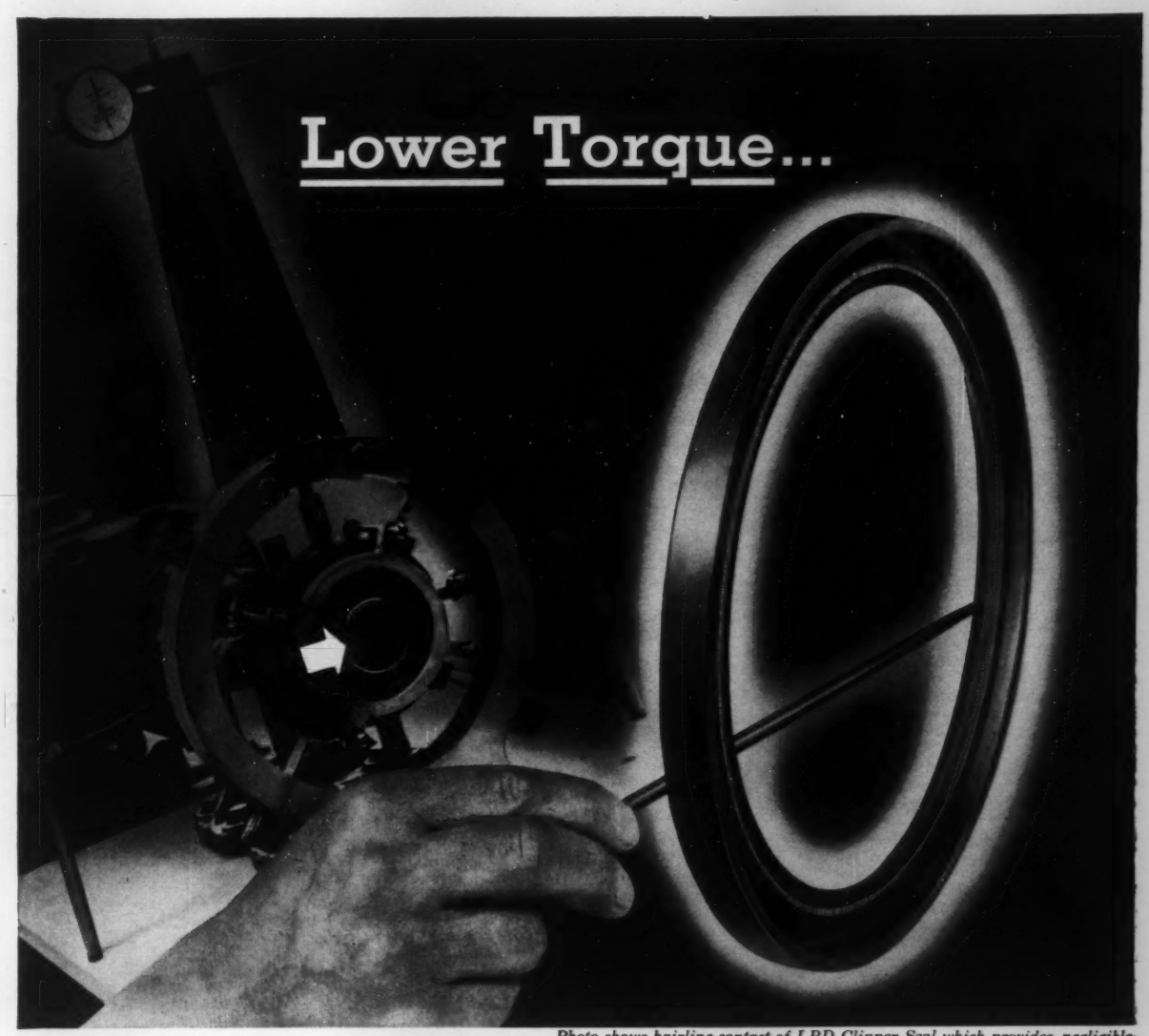


Photo shows hairline contact of LPD Clipper Seal which provides negligible torque when seal is tested on dry run of torque measuring apparatus.

How J-M Clipper Oil Seals cut shaft drag

line contact minimizes interference... provides cooler running

Take a close look at the lip of a Johns-Manville Clipper Seal. You'll see how the bearing area has been narrowed down to a sharp line contact. That's why you get less power consumption and lower operating temperatures when you use Clipper Seals to seal in lubricant, seal out dirt.

What's more, this line contact requires less lubrication and yet receives far more in proportion to its surface than any other design. It all adds up to greater sealing efficiency and longer seal life for Clipper Seal users. This exclusive line contact feature is provided on all LPD Clipper Seal designs which are adaptable to most applications.

Lower torque is only one of many advantages you get with J-M Clipper Seals. Precision moulded from a variety of corrosion-resistant compounds specially developed for each service, they provide maximum sealing ability, long life, wide adaptability and easy installation. For more information on the complete line of Clipper Seals, write for new 28-page illustrated brochure PK-71A. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada: 565 Lakeshore Road East, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

Circle 533 on page 19

Fastener Facts

DESIGN PRODUCTION & PURCHASING DATA

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

SHOULDERED RIVETS vs MACHINED PARTS

Both Act as Pivots!

When design calls for fasteners that also function as pivots for moving parts, it pays to consider shouldered rivets first. They may look much like screw machine parts that offer similar shoulder and tenon combinations; but the similarity ends there.

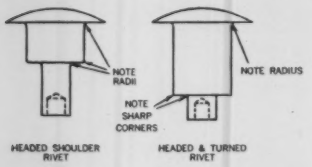
Rivets Cost Less!

Shouldered rivets cost only about half what you pay for their fully machined equivalents. That's because they can be cold-forged from solid wire in a single, high-speed operation. In most cases, no metal is removed, as with screw machine parts. So, you get all the stock you pay for.

Rivets Speed up Assembly!

Shouldered rivets are located and clinched by high-speed rivet-setting machines. Like semi-tubular rivets, they have shallow punched or drilled holes in their shanks to combine the shear and compression strength of solid rivets with low-cost fastening. On the other hand, comparable screw machine parts often require slow, costly hand locating and fastening.

Therefore, the savings in material and labor costs inherent in shouldered rivets demand their early consideration in cost reduction or value analysis programs. These low-cost, high-speed fasteners should be thoroughly investigated before designs are frozen in favor of more expensive screw machine parts.

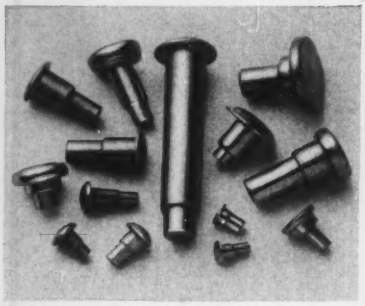


Thomson Shouldered Rivets

Thomson designs and produces shouldered rivets to specifications in two forms; completely cold-headed or cold-headed and turned, depending on permissible radius of corners and break of edges.

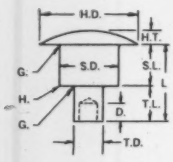
When close tolerances are not a factor as in folding baby carriages, car beds and seats, rollaway beds and comparable pivot-fastener applications, Thomson shouldered rivets are completely cold-headed . . . and, of course, priced at a minimum.

Where tighter fits are necessary, a secondary turning operation supplements the initial cold-forming to



square corners and edges to specified tolerances. Metal removal, of course is slight. As a result, these Thomson shouldered rivets cost slightly more than completely headed rivets, but much less then fully-turned parts.

Variables to Consider



In addition to permissible radius of corners (H) and break of edges (G), there are nine other design factors: head shape, the diameter (HD) and thickness (HT); shoulder diameter (SD) and length (SL); tenon diameter (TD) and length (TL); rivet length under head (L) and hole depth (D). Head shapes may be round, oval, flat, countersunk, or some special design. Because of all these variables, Thomson Shouldered Rivets are made to order after individual quotations.

Other Design Factors

It pays to think twice before you rule out shouldered rivets because of design and production consideration that seem to prevent insertion of rivet-setting machine's driver or anvil for clinching the rivets. In many cases, a slight change in spacing or cavity size allows use of rivets without changing overall dimensions. In other cases, a change in assembly sequence permits a profitable switch from costly hand assembly of expensive screw machine parts to low-cost machine-set rivets. Our engineering department, experienced in shouldered rivet applications, will be glad to offer suggestions while your designs are still in the rough-draft stage—at little or no cost.

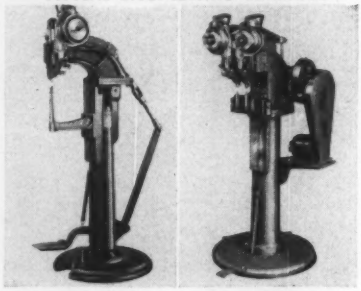
Materials and Finishes

Thomson Shouldered Rivets are produced from aluminum, brass, copper, nickel-silver, low-carbon steel, stainless steel and other materials. They can be plated with brass, cadmium, copper, nickel, tin, zinc, etc. They can also be oxidized or finished in japanned colors to match the original equipment or end product.

Thomson High-Speed Machines

The inherent economy of shouldered rivets as pivot-fasteners is multiplied by high-speed assembly made possible by automatic rivet-setting machines which can be operated by unskilled labor. Thomson, inventor of the first automatic-feed rivet-setting machine, has developed more than 250 styles which can do thousands of fastening jobs . . . with or without adaptations. Multiple rivet-setting heads, special work handling and loading fixtures are optional features that further accelerate assembly operations. Thomson will select and custom tool the proper machines to speed assembly and reduce costs in your plant. You can either buy or lease them and Thomson's sales-service engineers are available to keep them in top operating conditions.

TYPICAL RIVET-SETTING MACHINES



FLOOR-TYPE FOOT-OPERATED

FLOOR-TYPE MOTOR-OPERATED

Design and Engineering Service

Contacted while designs can still be modified, we will analyze your pivot-fastening problems and tell you whether shouldered rivets are best for you . . . at little or no cost. Send sketches or prints, if samples are not available.

Free "Fastener Fact File"

(Soon to be released)

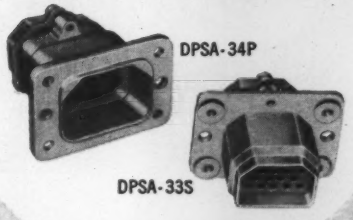
Be one of the first to profit from our new manual on all phases of riveting. It covers rivet types, applications, materials, finishes and other factors that determine selection of the right rivet design and machine for cutting fastening costs. Reserve your copy today. Write: Judson L. Thomson, Mfg. Co. Dept B, Waltham 54, Mass.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

Circle 534 on page 19

New!

DPS Connectors for High Altitudes-Vibration



These rack/panel pressurized connectors are designed for high altitude and vibration applications. When the DPS connector is mated, it is sealed about the insert faces by means of a specially designed rubber seal, that allows an axial tolerance of up to 1/8" while still effecting a seal. This seal is encased in the #34 shell so that the step down design of the mating #33 shell seats into and against it. In addition, the #34 or pin insert shell encloses a monobloc silicone insert designed so that the tightening of the junction shell effects a compression seal around the wires that have been inserted. The #33 or socket insert shell has a plastic front insulator, to insure alignment of contacts, and is backed up by a silicone rear insulator that is also tapered to permit the corresponding taper of the junction shell to compress it around the wires as the junction shell is tightened. Contacts for DPS connectors must be ordered separately, and installed at time of wiring. Co-axial contacts, and thermocouple contacts are available. Also, air lines. DPS connectors are available in 4 different sizes with several insert arrangements for each size.

Write for Bulletin DP-101 TODAY!

WHAT'S NEW FOR YOU

New!

Coaxial Connector Screw Type Coupling

TNC Coaxial Receptacle SA-445

Latest RF Connector Series — The TNC. The TNC is a screw type coupling version of the improved BNC series for small coaxial connectors. This TNC series, made by the Eastern Division of Cannon Electric, is available in two types: low voltage and high voltage. Both types are ideal where minimum noise is desired. They are lightweight, waterproof, sealed connectors which will operate at any altitude.

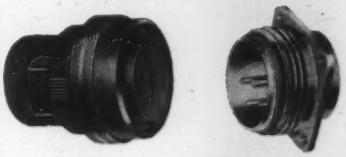
The high voltage TNC is recommended for AC rating up to 5,000 volts. Low voltage rating is to 500 volts. The TNC series is also available with collet cable clamp.

Write for RF Coaxial Bulletin DC-1 TODAY!

IN CANNON PLUGS

New!

Quick-Disconnect Accessories for AN-Plugs



CA06BQ Plug CA02AQ Receptacle

An accessory that consists of coupler and an adapter has been recently perfected by Cannon to provide quick connect and quick disconnect characteristics to AN connectors.

The adapter is designed to screw over the coupling threads of a standard AN receptacle, and contains an external locking groove which receives the formed ends of the coupler latch when fully engaged. The entry of the coupler latch into this groove permits a compression spring to move the coupler sleeve forward, locking the parts securely. A simple straight pull back on the sleeve releases the latch and permits disconnection.

The coupler consists of a special spring latch assembly, and is designed to replace the coupling nuts on Cannon AN3106A and AN3106B plugs.

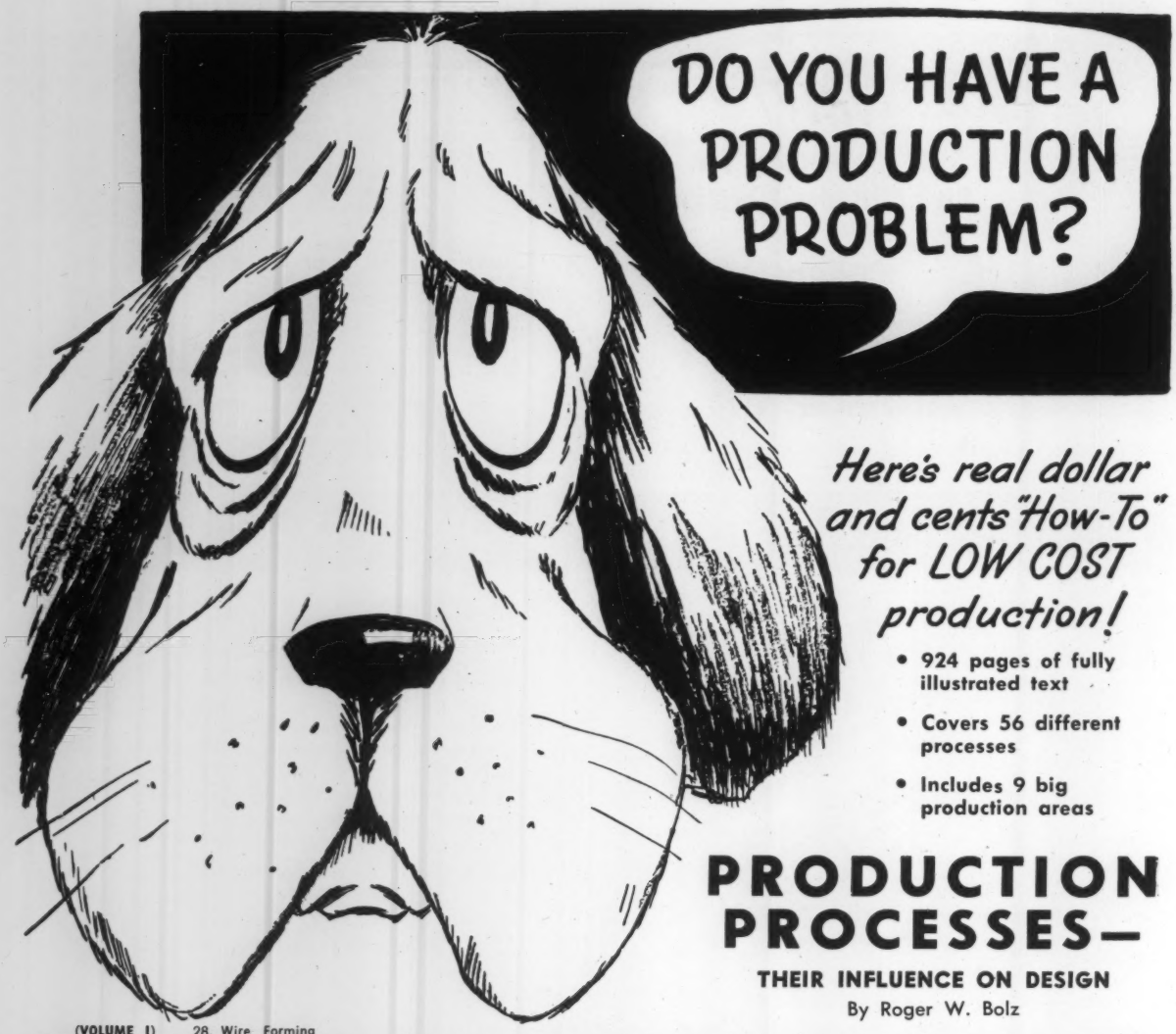
Write for Bulletin PR-QD TODAY!

CANNON PLUGS
WHERE RELIABILITY IS THE 5TH DIMENSION

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, London, Melbourne. Manufacturing licensees in Paris, Tokyo. Representatives and distributors in all principal cities.

CANNON ELECTRIC

Please refer to Dept. 185



Here's real dollar and cents "How-To" for LOW COST production!

- **924 pages of fully illustrated text**
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- **Includes 9 big production areas**

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THEIR INFLUENCE ON DESIGN

By Roger W. Bolz

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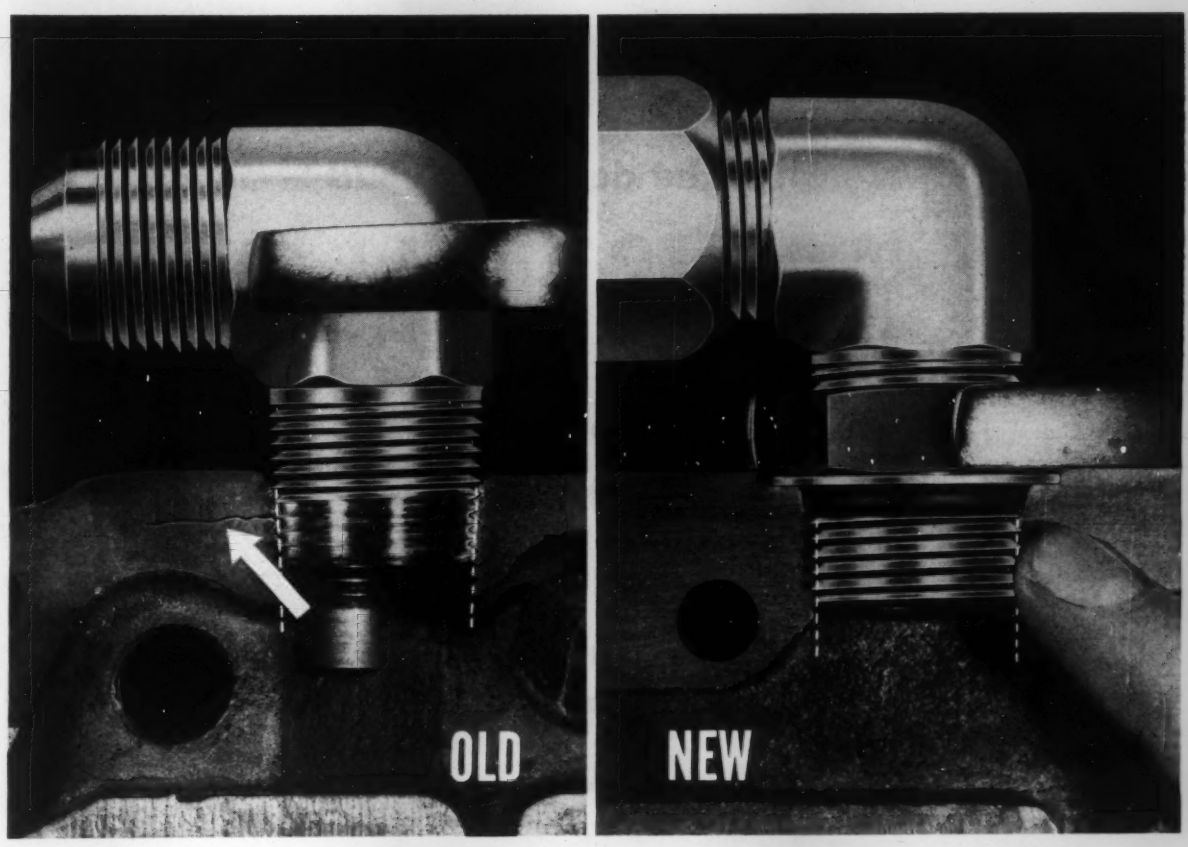
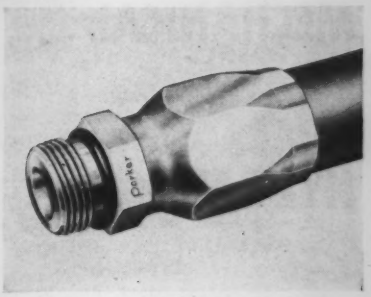


How Parker straight-thread fittings solve leakage problems

Forget about danger of cracking or distorting valve bodies by over-tightening the fittings. Forget about messy pipe "dope." Forget about leakage problems resulting from tapered pipe threads in high-pressure hydraulic systems.

Eliminate these problems. Use Parker O-ring seal straight-thread fittings (which conform with the SAE Standard for Hydraulic Tube Fittings) for leakproof, trouble-free connections. Available on Parker *Triple-lok* (the industrial standard flare tube fitting) and on Parker *Ferulok* (flareless fitting for heavy steel tubing).

Ask your Parker Distributor today, or mail the coupon for complete information about Parker straight-thread fittings.



New, Broader Line of *Hoze-lok* fittings for medium- and high-pressure hydraulic service. Longer performance, greater re-usability. No skiving of hose. Easier make-up saves time and money.

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Please send:
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Parker
Hydraulic and fluid system components

Circle 536 on page 19

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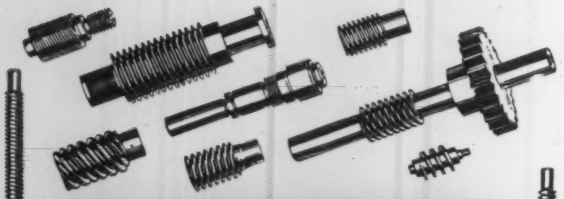

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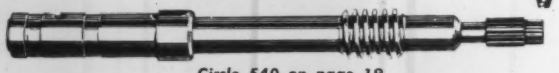

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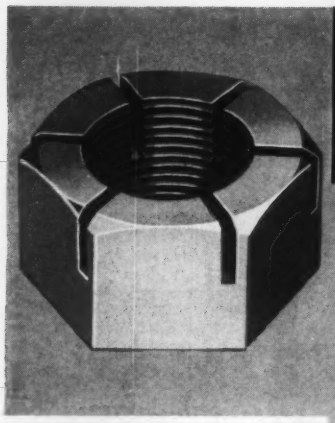

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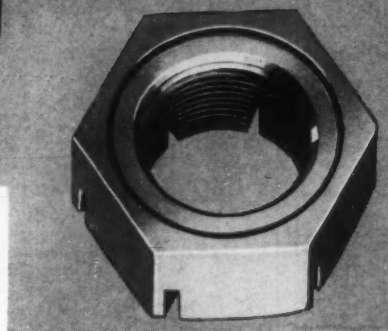
free running lock nut



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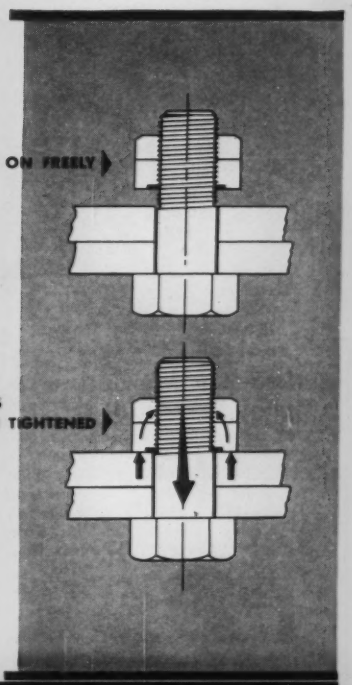

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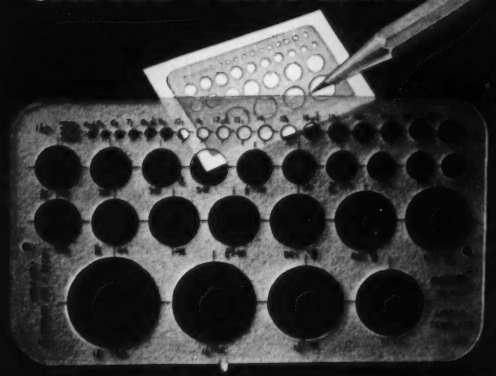

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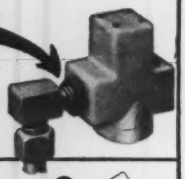

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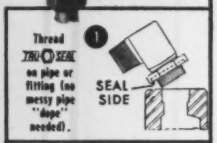
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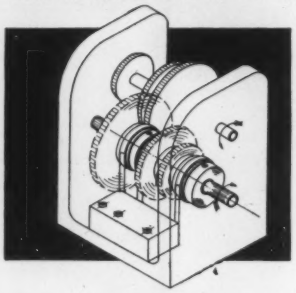

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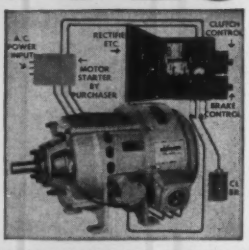

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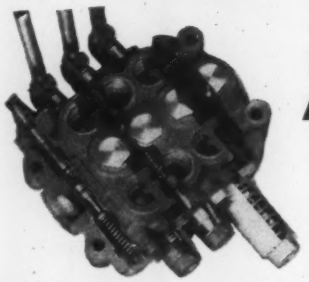
Versatile!

New HUSCO "3200" Valve Offers Power-Saving *Multi-Position* Control



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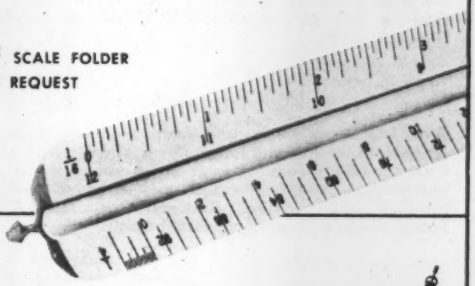

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SIGNAL LIGHTS
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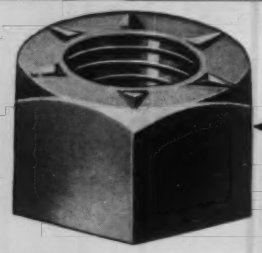

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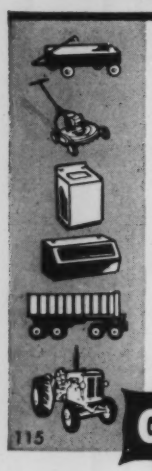
They increase product durability at low initial cost



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all with or without the famous Gripco positive locking feature. Also Standard Semi-Finish Nuts.

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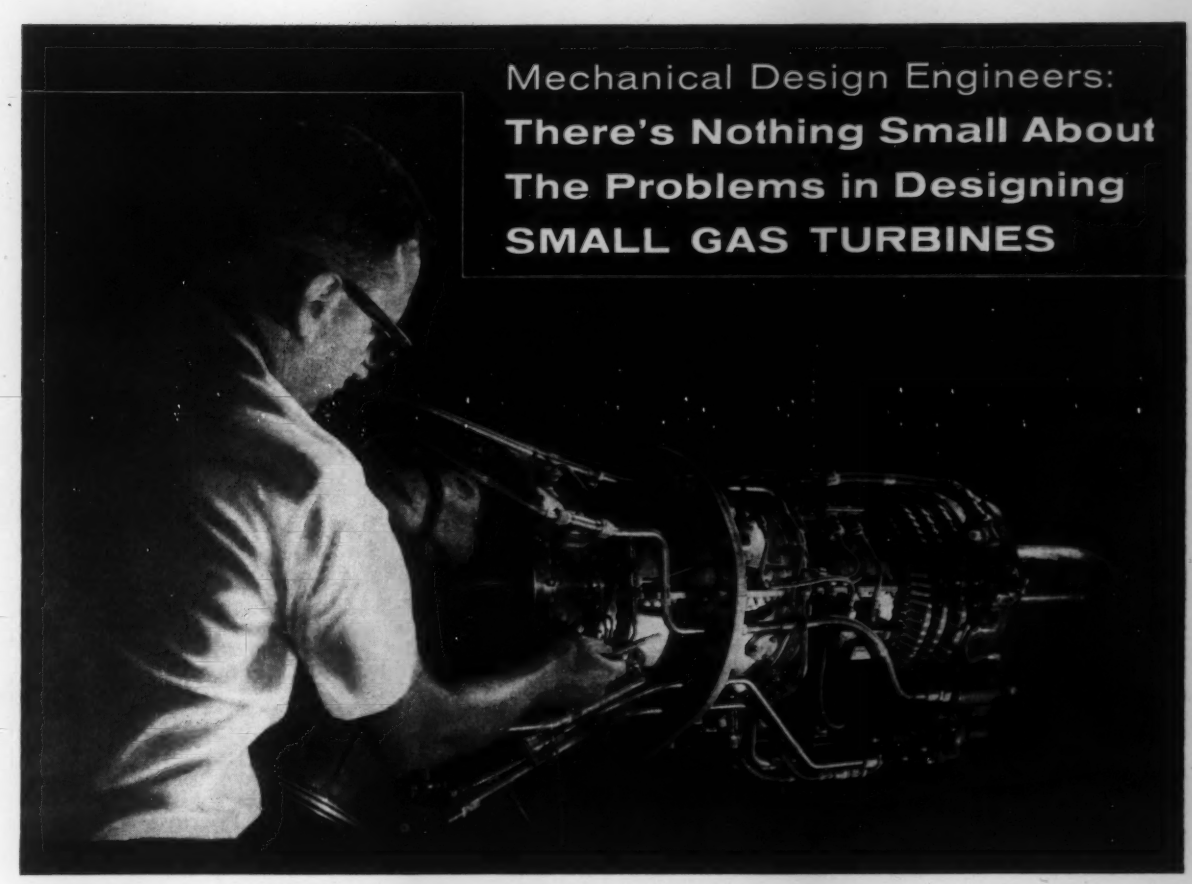

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Kurt Hain, Kinematic Research Scientist, Braunschweig, Germany

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Prof. Harold A. Rothbart, The City College of New York

DESIGN OF A CONSTANT-LOAD CAM
John A. Carlson, Product Development, Teletype Corp.

A HIGH-SPEED INDEXING MECHANISM
Ray C. Johnson, Senior Design Engineer, Eastman Kodak Co.

Session 2B

KINEMATIC SYNTHESIS VIA COMPLEX NUMBERS
Prof. Richard S. Hartenberg, Northwestern Univ.

KINEMATIC ANALYSIS VIA COMPLEX NUMBERS
Prof. G. H. Martin, Michigan State Univ.

ALTERNATE FOUR-BAR MECHANISMS
Prof. A. S. Hall Jr., Purdue Univ.

Banquet

UNLOCKING HUMAN CREATIVITY
Dr. Richard W. Wallen, Senior Associate, Creelman Associates, Cleveland, O.

Session 3

ANTICIPATING DYNAMIC BEHAVIOR
Prof. J. B. Hartman, Lehigh Univ.

PREDICTING IMPACT FORCES
Ray C. Johnson, Senior Design Engineer, Eastman Kodak Co.

LINKAGES USING RACKS AND PINIONS
Erwin P. Pollitt, Senior Research Engineer, Armour Research Foundation

Session 4

THE DOUBLE-CRANK LINKAGE
Kurt Hain, Kinematic Research Scientist, Braunschweig, Germany

DWELL LINKAGES VS. CAMS
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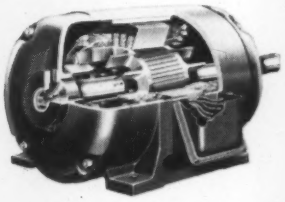

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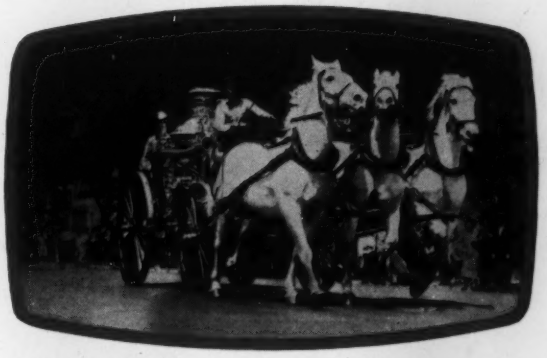

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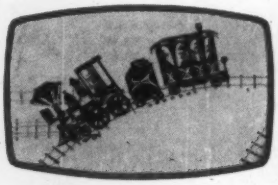

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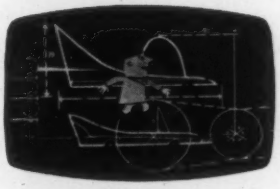

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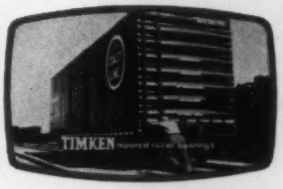

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